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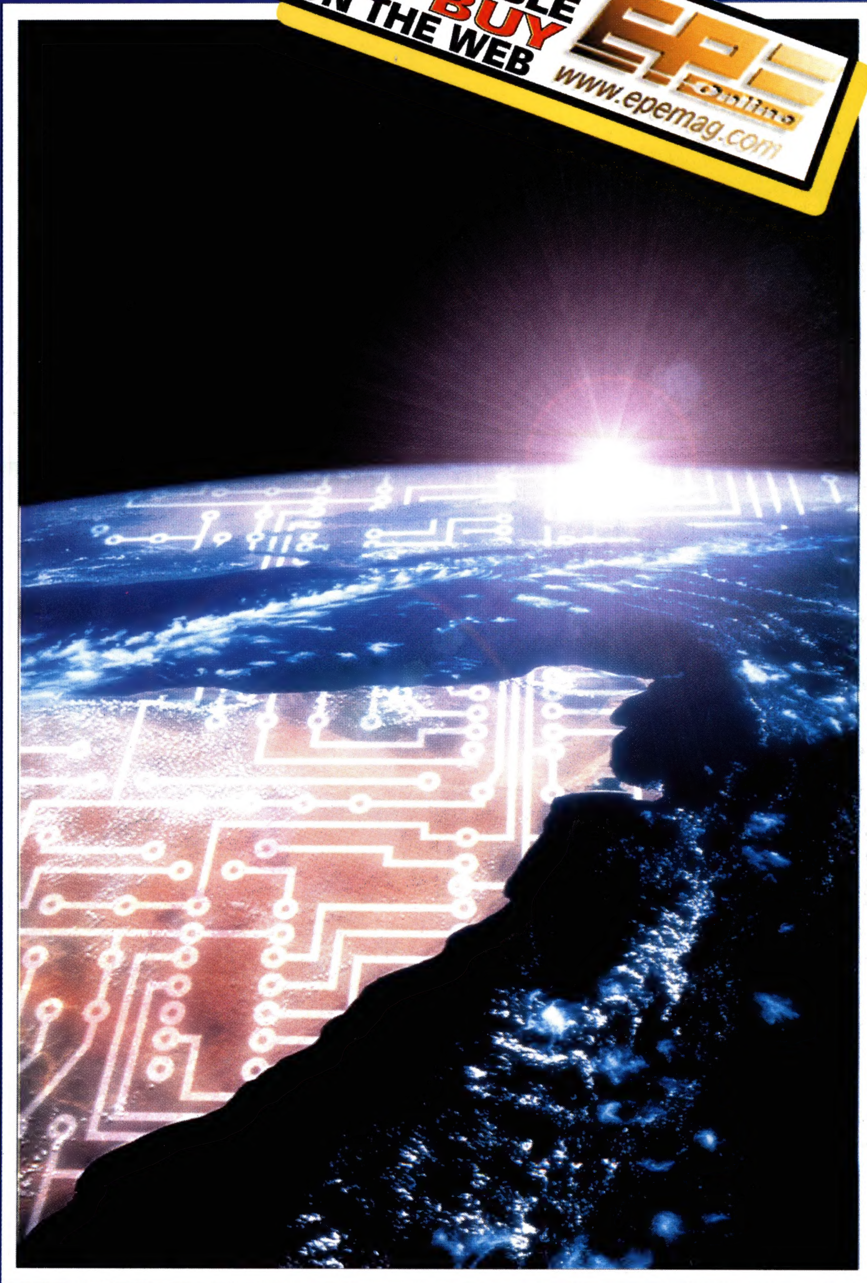

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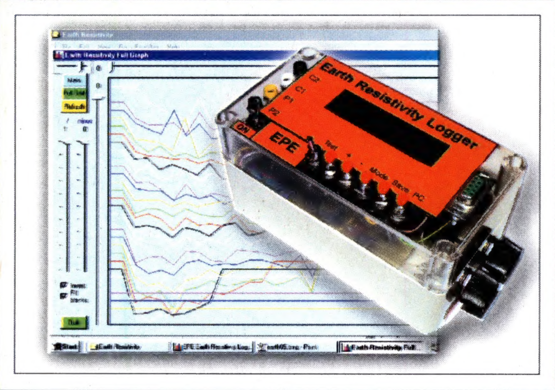
See beneath the soil



ATMOSPHERICS MONITOR

Tune in to the sounds of the heavens

PLUS

BACK TO BASICS 3

Two easy to build projects

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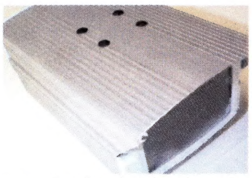
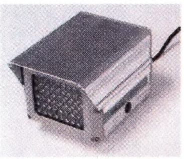
Colour CCTV camera, 8mm lens, 12V d.c. 200mA 582x628 Resolution 380 lines Automatic aperture lens Mirror function PAL Back Light Compensation MLR, 100x40x40mm. Ref EE2 £69

Built-in Audio .15lux CCD camera 12V d.c. 200mA 480 lines s/n ratio >48db 1v P-P output 110x60x50mm. Ref EE1 £99



Metal CCTV camera housings for internal or external use. Made from aluminium and plastic they are suitable for mounting body cameras in. Available in two sizes 1 – 100x10x170mm and 2 – 100x70x280mm. Ref EE6 £22 EE7 £26 multi-position brackets. Ref EE8 £8

Excellent quality multi-purposeTV/TFT screen, works as just a LCD colour monitor with any of our CCTV cameras or as a conventional TV. Ideal for use in boats and caravans 49.7MHz-91.75MHz VHF channels 1-5,168.25MHz-222.75MHz VHF channels 6-12, 471.25MHz-869.75MHz, Cable channels 112.325MHz-166.75MHz Z1-Z7, Cable channels 224.25MHz-446.75MHz Z8-Z35 5" colour screen. Audio output 150mW. Connections, external aerial, earphone jack, audio/video input, 12V d.c. or mains, Accessories supplied Power supply, Remote control, Cigar lead power supply, Headphone Stand/bracket. 5" model £139 Ref EE9, 6" model £149. Ref EE10

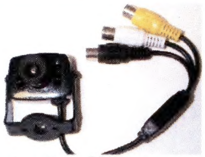


Fully cased IR light source suitable for CCTV applications. The unit measures 10x10x150mm, is mains operated and contains 54 infra-red LEDs. Designed to mount on a standard CCTV camera bracket. The unit also contains a daylight sensor that will only activate the infra red lamp when the light level drops below a preset level. The infrared lamp is suitable for indoor or exterior use, typical useage would be to provide additional IR illumination for CCTV cameras. £49. Ref EE11

This device is mains operated and designed to be used with a standard CCTV camera causing it to scan. The black clips can be moved to adjust the span angle, the motor reversing when it detects a clip. With the clips removed the scanner will rotate constantly at approx 2.3rpm. 75x75x80mm £23. Ref EE12

Colour CCTV Camera measures 60x45mm and has a built in light level detector and 12 IR LEDs .2 lux 12 IR LEDs 12V d.c. Bracket Easy connect leads £69. Ref EE15

A high quality external colour CCTV camera with built in Infra-red LEDs measuring 60x60x60mm Easy connect leads colour Waterproof PAL 1/4' CCD 542x588 pixels 420 lines .05 lux 3.6mm F2 78 deg lens 12V d.c. 400mA Built in light level sensor. £99. Ref EE13



A small compact colour CCTV camera measuring just 35x28x30mm (camera body) Camera is supplied complete with mounting bracket, built in IR, microphone and easy connect leads. Built in audio Built in IR LEDs Colour 380 line resolution PAL 0.2 us +18db sensitivity. Effective pixels 628x582 Power source 6-12V d.c. Power consumption 200mW £36. Ref EE16

Complete wireless CCTV sytem with video. Kit comprises pinhole colour camera with simple battery connection and a receiver with video output. 380 lines colour 2.4GHz 3 lux 6-12V d.c. manual tuning Available in two versions, pinhole and standard. £79 (pinhole) Ref EE17, £79 (standard). Ref EE18

Small transmitter designed to transmit audio and video signals on 2.4GHz. Unit measures 45x35x10mm.Ideal for assembly into covert CCTV systems Easy connect leads Audio and video input 12V d.c. Complete with aerial Selectable channel switch £30. Ref EE19

2.4GHz wireless receiver Fully cased audio and video 2.4GHz wireless receiver 190x140x30mm, metal case, 4 channel, 12V d.c. Adjustable time delay, 4s, 8s, 12s, 16s. £45. Ref EE20

Colour pinhole cctv camera module with audio Compact colour pinhole camera measuring just 20x20x20mm, built-in audio and easy connect leads PAL CMOS sensor 6-9V d.c. Effective Pixels 628x582 Illumination 2 lux Definition >240 Signal/noise ratio >40db Power consumption 200mW £35. Ref £35

Self-cocking pistol plcr002 crossbow with metal body. Self-cocking for precise string alignment Aluminium alloy construction High tec fibre glass limbs Automatic safety catch Supplied with three bolts Track style for greater accuracy. Adjustable rearsight 50lb drawweight 150ft sec velocity Break action 17" string 30m range £21.65 Ref PLCR002 **INFRA-RED FILM** 6" square piece of flexible infra-red film that will only allow IR light through. Perfect for converting ordinary torches, lights, headlights etc to infra-red output only using standard light bulbs Easily cut to shape. 6" square £15. Ref IRF2 or a 12" sq for £29 IRF2A **NEW 12V 12" SQUARE SOLAR PANEL** Kevlar backed, 3watt output. Copper strips for easy solder connections £14.99. Ref 15P42 **PACK OF 4 JUST £39.95. REF 15P42SP**

Dummy CCTV cameras These motorised cameras will work either on 2 AA batteries or with a standard DC adapter (not supplied) They have a built in movement detector that will activate the camera if movement is detected causing the camera to 'pan' Good deterrent. Camera measures 20cm high, supplied with rawl plugs and fixing screws. Camera also has a flashing red LED built in. £9.95. Ref CAMERAB

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Beltronics BEL55O Euroradarand GATSO detector Claimed Detection Range: GATSO up 400m. Radar & Laser guns up to 3 miles. Detects GATSO speed cameras at least 200 metres away, plenty of time to adjust your speed £319. Ref BEL550

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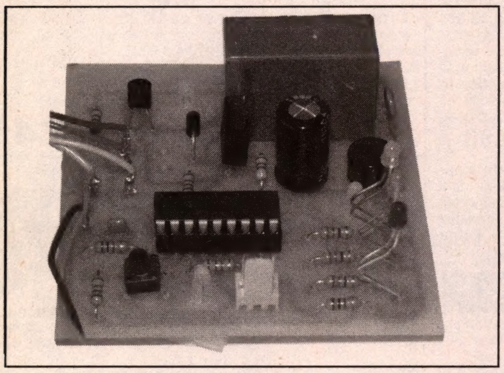

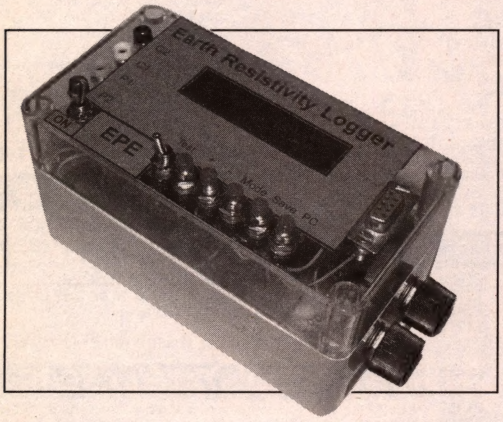

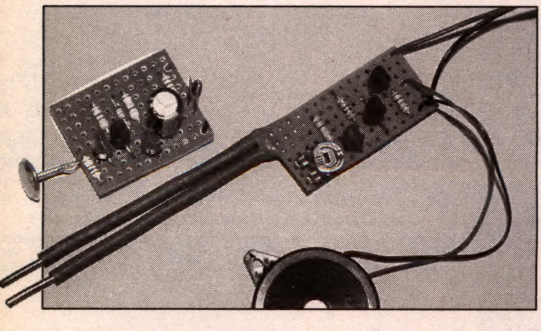

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Quite simply the best low-cost way to learn about using PICs! An enhanced revision of our highly acclaimed series of 1998.

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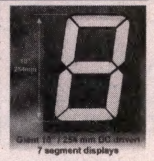

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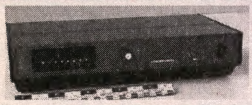

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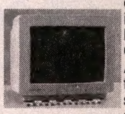

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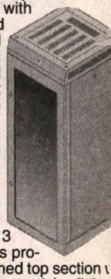

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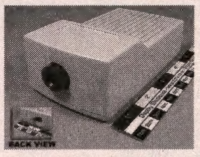

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IBM 53F5501 Token Ring ICS 20 port lobe modules	**£POA**
IBM MAU Token ring distribution panel 8228-23-5050N	**£45**
AIM 501 Low distortion Oscillator 9Hz to 330Khz, IEEE I/O	**£550**
ALLGON 8360.11805-1880 MHz hybrid power combiners	**£250**
Trend DSA 274 Data Analyser with G703(2M) 64 i/o	**£POA**
Marconi 6310 Programmable 2 to 22 GHz sweep generator	**£4500**
Marconi 2022C 10KHz-1GHz RF signal generator	**£1550**
HP1650B Logic Analyser	**£3750**
HP3781A Pattern generator & **HP3782A** Error Detector	**£POA**
HP6621A Dual Programmable GPIB PSU 0-7 V 160 watts	**£1800**
HP6264 Rack mount variable 0-20V @ 20A metered PSU	**£475**
HP54121A DC to 22 GHz four channel test set	**£POA**
HP8130A opt 020 300 MHz pulse generator, GPIB etc	**£7900**
HP A1, A0 8 pen HPGL high speed drum plotters - from	**£550**
HP DRAFTMASTER 1 8 pen high speed plotter	**£750**
EG+G Brookdeal 95035C Precision lock in amp	**£1800**
Keithley 590 CV capacitor / voltage analyser	**£POA**
Racal ICR40 dual 40 channel voice recorder system	**£3750**
Fiskers 45KVA 3 ph On Line UPS – New batteries	**£4500**
Emerson AP130 2.5KVA industrial spec.UPS	**£1499**
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Intel SBC 486/125C08 Enhanced Multibus (MSA) **New**	**£1150**
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PHILIPS PM5518 pro. TV signal generator	**£1250**
Motorola VME Bus Boards & Components List. SAE / CALL	**£POA**
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Fujitsu M3041D 600 LPM printer with network interface	**£1250**
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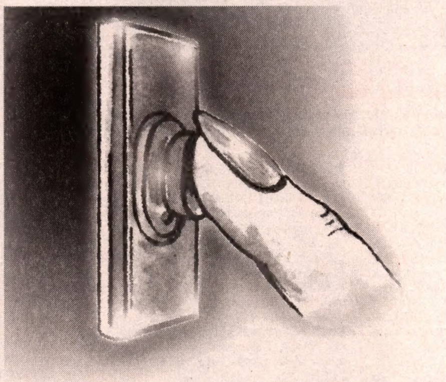
NEXT MONTH

FREE SUPPLEMENT PIC TUTORIAL V2 Part 2

DOOR CHIME



Recreate the nostalgic "Ding Dong" chime with this design. Employs a handful of active components, including a power amplifier i.c., to give a realistic chime sound from a small p.c.b. supplied by a 9V PP3 battery. The note frequencies can be altered to meet individual preferences.

SUPER MOTION SENSOR

This relatively simple unit – it employs just three i.c.s and a couple of transistors – will detect a single finger moving at a distance of five metres, or a person crossing a path at 20 metres. The circuit responds to fluctuations in light level and is thus much more flexible than a typical "light beam" system.

Requiring no setting up, the unit auto-adjusts over the range of about 50 lux to 60,000 lux and it can thus be used without a dedicated light source in a wide variety of daylight situations, or with virtually any a.c. lighting source.

PLUS

BACK TO BASICS

Live Wire Detector and MW Radio. Two more simple, easy to build projects.

The Live Wire Detector uses just six components to detect live mains wires, to locate breaks in mains circuits and to test light bulbs, fuses and relay coils for continuity. Another three transistor project, the MW Radio is a simple regenerative design that is fun to build and use.

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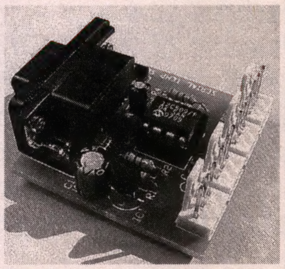
Our electronic kits are supplied complete with all components, high quality PCBs (NOT cheap Tripad strip board!) and detailed assembly/operating instructions

● **2 x 25W CAR BOOSTER AMPLIFIER** Connects to the output of an existing car stereo cassette player, CD player or radio. Heatsinks provided. PCB 76x75mm. **1046KT. £24.95**
● **3-CHANNEL WIRELESS LIGHT MODULATOR** No electrical connection with amplifier. Light modulation achieved via a sensitive electret microphone. Separate sensitivity control per channel. Power handing 400W/channel. PCB 54x112mm. Mains powered. Box provided. **6014KT £24.95**
● **12 RUNNING LIGHT EFFECT** Exciting 12 LED light effect ideal for parties, discos, shop-windows & eye-catching signs. PCB design allows replacement of LEDs with 220V bulbs by inserting 3 TRIACs. Adjustable rotation speed & direction. PCB 54x112mm. **1026KT £15.95; BOX (for mains operation) 2026BX £9.00**
● **DISCO STROBE LIGHT** Probably the most exciting of all light effects. Very bright strobe tube. Adjustable strobe frequency: 1-60Hz. Mains powered. PCB: 60x68mm. Box provided. **6037KT £28.95**

● **ANIMAL SOUNDS** Cat, dog, chicken & cow. Ideal for kids farmyard toys & schools. **SG10M £5.95**
● **3 1/2 DIGIT LED PANEL METER** Use for basic voltage/current displays or customise to measure temperature, light, weight, movement, sound levels, etc. with appropriate sensors (not supplied). Various input circuit designs provided. **3061KT £13.95**
● **IR REMOTE TOGGLE SWITCH** Use any TV/VCR remote control unit to switch onboard 12V/1A relay on/off. **3058KT £10.95**
SPEED CONTROLLER for any common DC motor up to 100V/5A. Pulse width modulation gives maximum torque at all speeds. 5-15VDC. Box provided. **3067KT £12.95**
● **3 x 8 CHANNEL IR RELAY BOARD** Control eight 12V/1A relays by Infra Red (IR) remote control over a 20m range in sunlight. 6 relays turn on only, the other 2 toggle on/off. 3 operation ranges determined by jumpers. Transmitter case & all components provided. Receiver PCB 76x89mm. **3072KT £52.95**

PRODUCT FEATURE

COMPUTER TEMPERATURE DATA LOGGER
PC serial port controlled 4-channel temperature meter (either deg C or F). Requires no external power. Allows continuous temperature data logging of up to four temperature sensors located 200m+ from motherboard/PC. Ideal use for old 386/486 computers. Users can tailor input data stream to suit their purpose (dump it to a spreadsheet or write your own BASIC programs using the INPUT command to grab the readings). PCB just 38mm x 38mm. Sensors connect via four 3-pin headers. 4 header cables supplied but only one DS18S20 sensor.
Kit software available free from our website.
ORDERING: 3145KT **£23.95** (kit form);
AS3145 **£29.95** (assembled);
Additional DS18S20 sensors **£4.95** each



● **SOUND EFFECTS GENERATOR** Easy to build. Create an almost infinite variety of interesting/unusual sound effects from birds chirping to sirens. 9VDC. PCB 54x85mm. **1045KT £8.95**
● **ROBOT VOICE EFFECT** Make your voice sound similar to a robot or Darlek. Great fun for discos, school plays, theatre productions, radio stations & playing jokes on your friends when answering the phone! PCB 42x71mm. **1131KT £8.95**
● **AUDIO TO LIGHT MODULATOR** Controls intensity of one or more lights in response to an audio input. Safe, modern opto-coupler design. Mains voltage experience required. **3012KT £8.95**
● **MUSIC BOX** Activated by light. Plays 8 Christmas songs and 5 other tunes. **3104KT £7.95**
● **20 SECOND VOICE RECORDER** Uses non-volatile memory - no battery backup needed. Record/replay messages over & over. Playback as required to greet customers etc. Volume control & built-in mic. 6VDC. PCB 50x73mm.
3131KT £12.95
● **TRAIN SOUNDS** 4 selectable sounds : whistle blowing, level crossing bell, 'clickety-clack' & 4 in sequence. **SG01M £6.95**

● **PC CONTROLLED RELAY BOARD**
Convert any 286 upward PC into a dedicated automatic controller to independently turn on/off up to eight lights, motors & other devices around the home, office, laboratory or factory. Each relay output is capable of switching 250VAC/4A. A suite of DOS and Windows control programs are provided together with all components (except box and PC cable). 12VDC. PCB 70x200mm. **3074KT £31.95**
● **2 CHANNEL UHF RELAY SWITCH** Contains the same transmitter/receiver pair as 30A15 below plus the components and PCB to control two 240VAC/10A relays (also supplied). Ultra bright LEDs used to indicate relay status. **3082KT £27.95**
● **TRANSMITTER RECEIVER PAIR** 2-button keyfob style 300-375MHz Tx with 30m range. Receiver encoder module with matched decoder IC. Components must be built into a circuit like kit 3082 above. **30A15 £14.95**
● **PIC 16C71 FOUR SERVO MOTOR DRIVER** Simultaneously control up to 4 servo motors. Software & all components (except servos/control pots) supplied. 5VDC. PCB 50x70mm. **3102KT £15.95**
● **UNIPOLAR STEPPER MOTOR DRIVER** for any 5/6/8 lead motor. Fast/slow & single step rates. Direction control & on/off switch. Wave, 2-phase & half-wave step modes. 4 LED indicators. PCB 50x65mm. **3109KT £14.95**
● **PC CONTROLLED STEPPER MOTOR DRIVER** Control two unipolar stepper motors (3A max. each) via PC printer port. Wave, 2-phase & half-wave step modes. Software accepts 4 digital inputs from external switches & will single step motors. PCB fits in D-shell case provided. **3113KT £17.95**
● **12-BIT PC DATA ACQUISITION/CONTROL UNIT** Similar to kit 3093 above but uses a 12 bit Analogue-to-Digital Converter (ADC) with internal analogue multiplexor. Reads 8 single ended channels or 4 differential inputs or a mixture of both. Analogue inputs read 0-4V. Four TTL/CMOS compatible digital input/outputs. ADC conversion time <10uS. Software (C, QB & Win), extended D shell case & all components (except sensors & cable) provided. **3118KT £52.95**
● **LIQUID LEVEL SENSOR/RAIN ALARM** Will indicate fluid levels or simply the presence of fluid. Relay output to control a pump to add/remove water when it reaches a certain level. **1080KT £5.95**
● **AM RADIO KIT 1** Tuned Radio Frequency front-end, single chip AM radio IC & 2 stages of audio amplification. All components inc. speaker provided. PCB 32x102mm. **3063KT £10.95**
● **DRILL SPEED CONTROLLER** Adjust the speed of your electric drill according to the job at hand. Suitable for 240V AC mains powered drills up to 700W power. PCB: 48mm x 65mm. Box provided. **6074KT £17.95**
● **3 INPUT MONO MIXER** Independent level control for each input and separate bass/treble controls. Input sensitivity: 240mV. 18V DC. PCB: 60mm x 185mm **1052KT £16.95**
● **NEGATIVE\POSITIVE ION GENERATOR** Standard Cockcroft-Walton multiplier circuit. Mains voltage experience required. **3057KT £10.95**
● **LED DICE** Classic intro to electronics & circuit analysis. 7 LED's simulate dice roll, slow down & land on a number at random. 555 IC circuit. **3003KT £9.95**
● **STAIRWAY TO HEAVEN** Tests hand-eye co-ordination. Press switch when green segment of LED lights to climb the stairway - miss & start again! Good intro to several basic circuits. **3005KT £9.95**
● **ROULETTE LED** 'Ball' spins round the wheel, slows down & drops into a slot. 10 LED's. Good intro to CMOS decade counters & Op-Amps. **3006KT £10.95**
● **12V XENON TUBE FLASHER TRANSFORMER** steps up a12V supply to flash a 25mm Xenon tube. Adjustable flash rate. **3163KT £13.95**
● **LED FLASHER 1** 5 ultra bright red LED's flash in 7 selectable patterns. **3037MKT £5.95**
● **LED FLASHER 2** Similar to above but flash in sequence or randomly. Ideal for model railways. **3052MKT £5.95**
● **INTRODUCTION TO PIC PROGRAMMING.** Learn programming from scratch. Programming hardware, a P16F84 chip and a two-part, practical, hands-on tutorial series are provided. **3081KT £21.95**
● **SERIAL PIC PROGRAMMER** for all 8/18/28/40 pin DIP serial programmed PICs. Shareware software supplied limited to programming 256 bytes (registration costs £14.95). **3096KT £10.95**
● **ATMEL 89Cx051 PROGRAMMER** Simple-to-use yet powerful programmer for the Atmel 89C1051, 89C2051 & 89C4051 uC's. Programmer does NOT require special software other than a terminal emulator program (built into Windows). Can be used with ANY computer/operating system. **3121KT £24.95**
● **3V/1.5V TO 9V BATTERY CONVERTER** Replace expensive 9V batteries with economic 1.5V batteries. IC based circuit steps up 1 or 2 'AA' batteries to give 9V/18mA. **3035KT £5.95**
● **STABILISED POWER SUPPLY 3-30V/2.5A** Ideal for hobbyist & professional laboratory. Very reliable & versatile design at an extremely reasonable price. Short circuit protection. Variable DC voltages (3-30V). Rated output 2.5 Amps. Large heatsink supplied. You just supply a 24VAC/3A transformer. PCB 55x112mm. Mains operation. **1007KT £16.95.**

● **STABILISED POWER SUPPLY 2-30V/5A** As kit 1007 above but rated at 5Amp. Requires a 24VAC/5A transformer. **1096KT £27.95.**
● **MOTORBIKE ALARM** Uses a reliable vibration sensor (adjustable sensitivity) to detect movement of the bike to trigger the alarm & switch the output relay to which a siren, bikes horn, indicators or other warning device can be attached. Auto-reset. 6-12VDC. PCB 57x64mm. **1011KT £11.95** Box **2011BX £7.00**
● **CAR ALARM SYSTEM** Protect your car from theft. Features vibration sensor, courtesy/boot light voltage drop sensor and bonnet/boot earth switch sensor. Entry/exit delays, auto-reset and adjustable alarm duration. 6-12V DC. PCB: 47mm x 55mm **1019KT £11.95** Box **2019BX £8.00**
● **PIEZO SCREAMER** 110dB of ear piercing noise. Fits in box with 2 x 35mm piezo elements built into their own resonant cavity. Use as an alarm siren or just for fun! 6-9VDC. **3015KT £10.95**
● **COMBINATION LOCK** Versatile electronic lock comprising main circuit & separate keypad for remote opening of lock. Relay supplied. **3029KT £10.95**
● **ULTRASONIC MOVEMENT DETECTOR** Crystal locked detector frequency for stability & reliability. PCB 75x40mm houses all components. 4-7m range. Adjustable sensitivity. Output will drive external relay/circuits. 9VDC. **3049KT £13.95**
● **PIR DETECTOR MODULE** 3-lead assembled unit just 25x35mm as used in commercial burglar alarm systems. **3076KT £8.95**
● **INFRARED SECURITY BEAM** When the invisible IR beam is broken a relay is tripped that can be used to sound a bell or alarm. 25 metre range. Mains rated relays provided. 12VDC operation. **3130KT £12.95**
● **SQUARE WAVE OSCILLATOR** Generates square waves at 6 preset frequencies in factors of 10 from 1Hz-100KHz. Visual output indicator. 5-18VDC. Box provided. **3111KT £8.95**
● **PC DRIVEN POCKET SAMPLER/DATA LOGGER** Analogue voltage sampler records voltages up to 2V or 20V over periods from milli-seconds to months. Can also be used as a simple digital scope to examine audio & other signals up to about 5KHz. Software & D-shell case provided. **3112KT £18.95**
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TELEPHONE SURVEILLANCE

● ***MTTX* - MINIATURE TELEPHONE TRANSMITTER** Attaches anywhere to phone line. Transmits only when phone is used! Tune-in your radio and hear both parties. 300m range. Uses line as aerial & power source. 20x45mm. **3016KT £8.95 AS3016 £14.95**
● ***TRI* - TELEPHONE RECORDING INTERFACE** Automatically record all conversations. Connects between phone line & tape recorder (not supplied). Operates recorders with 1.5-12V battery systems. Powered from line. 50x33mm. **3033KT £9.95 AS3033 £18.95**
● ***TPA* - TELEPHONE PICK-UP AMPLIFIER/WIRELESS PHONE BUG** Place pick-up coil on the phone line or near phone earpiece and hear both sides of the conversation. **3055KT £11.95 AS3055 £20.95**

HIGH POWER TRANSMITTERS

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● **4 WATT FM TRANSMITTER** Comprises three RF stages and an audio preamplifier stage. Piezoelectric microphone supplied or you can use a separate preamplifier circuit. Antenna can be an open dipole or Ground Plane. Ideal project for those who wish to get started in the fascinating world of FM broadcasting and want a good basic circuit to experiment with. 12-18VDC. PCB 44x146mm. **1028KT. £22.95 AS1028 £34.95**
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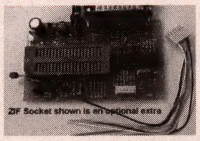

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*A 40 pin wide ZIF socket is required to program 0·3in. devices (Order Code AZIF40 @ £15.00).

Order Ref	Description	inc. VAT ea
3144KT	Enhanced 'PICALL' ISP PIC Programmer	**£59.95**
AS3144	Assembled Enhanced 'PICALL' ISP PIC Programmer	**£64.95**
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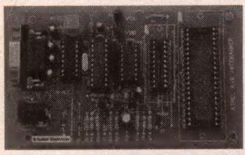
ATMEL AVR Programmer

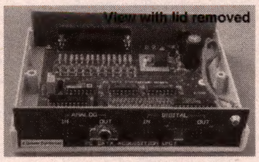


Powerful programmer for Atmel AT90Sxxxx (AVR) micro controller family. All fuse and lock bits are programmable. Connects to serial port. Can be used with ANY computer and operating system. Two LEDs to indicate programming status. Supports 20-pin DIP AT90S1200 & AT90S2313 and 40-pin DIP AT90S4414 & AT90S8515 devices. NO special software required – uses any terminal emulator program (built into Windows). The programmer is supported by BASCOM-AVR Basic Compiler software (see website for details).

Order Ref	Description	inc. VAT ea
3122KT	ATMEL AVR Programmer	**£24.95**
AS3122	Assembled 3122	**£34.95**

Atmel 89Cx051 and 89xxx programmers also available.

PC Data Acquisition & Control Unit



With this kit you can use a PC parallel port as a real world interface. Unit can be connected to a mixture of analogue and digital inputs from pressure, temperature, movement, sound, light intensity, weight sensors, etc. (not supplied) to sensing switch and relay states. It can then process the input data and use the information to control up to 11 physical devices such as motors, sirens, other relays, servo motors & two-stepper motors.

FEATURES:

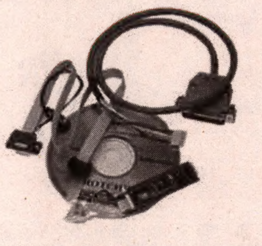
- 8 Digital Outputs: Open collector, 500mA, 33V max.
- 16 Digital Inputs: 20V max. Protection 1K in series, 5·1V Zener to ground.
- 11 Analogue Inputs: 0-5V, 10 bit (5mV/step.)
- 1 Analogue Output: 0-2·5V or 0-10V. 8 bit (20mV/step.)

All components provided including a plastic case (140mm x 110mm x 35mm) with pre-punched and silk screened front/rear panels to give a professional and attractive finish (see photo) with screen printed front & rear panels supplied. Software utilities & programming examples supplied.

Order Ref	Description	inc. VAT ea
3093KT	PC Data Acquisition & Control Unit	**£99.95**
AS3093	Assembled 3093	**£124.95**

See opposite page for ordering information on these kits

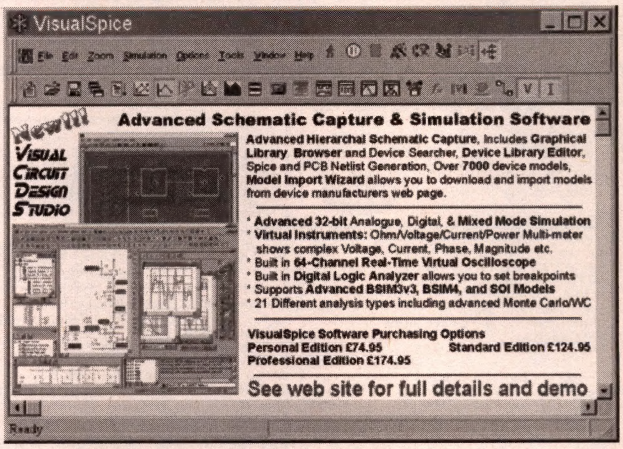
ABC Mini 'Hotchip' Board



Currently learning about microcontrollers? Need to do something more than flash a LED or sound a buzzer? The ABC Mini 'Hotchip' Board is based on Atmel's AVR 8535 RISC technology and will interest both the beginner and expert alike. Beginners will find that they can write and test a simple program, using the BASIC programming language, within an hour or two of connecting it up. Experts will like the power and flexibility of the ATMEL microcontroller, as well as the ease with which the little Hot Chip board can be "designed-in" to a project. The ABC Mini Board 'Starter Pack' includes just about everything you need to get up and experimenting right away. On the hardware side, there's a pre-assembled micro controller PC board with both parallel and serial cables for connection to your PC. Windows software included on CD-ROM features an Assembler, BASIC compiler and in-system programmer The pre-assembled boards only are also available separately.

Order Ref	Description	inc. VAT ea
ABCMINISP	ABC MINI Starter Pack	**£64.95**
ABCMINIB	ABC MINI Board Only	**£39.95**

Advanced 32-bit Schematic Capture and Simulation Visual Design Studio


VisualSpice
File Edit Zoom Simulation Options Tools Window Help
New!!!
Visual Circuit Design Studio
Ready

Advanced Schematic Capture & Simulation Software

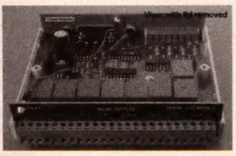
Advanced Hierarchal Schematic Capture, includes **Graphical Library Browser** and Device Searcher, **Device Library Editor**, Spice and PCB Netlist Generation, Over **7000** device models, **Model Import Wizard** allows you to download and import models from device manufacturers web page.

* **Advanced 32-bit** Analogue, Digital, & **Mixed Mode Simulation**
* **Virtual Instruments:** Ohm/Voltage/Current/Power Multi-meter shows complex Voltage, Current, Phase, Magnitude etc.
* Built in **64-Channel Real-Time Virtual Oscilloscope**
* Built in **Digital Logic Analyzer** allows you to set breakpoints
* Supports **Advanced BSIM3v3, BSIM4, and SOI Models**
* 21 Different analysis types including advanced Monte Carlo/WC

VisualSpice Software Purchasing Options
Personal Edition £74.95 **Standard Edition £124.95**
Professional Edition £174.95

See web site for full details and demo

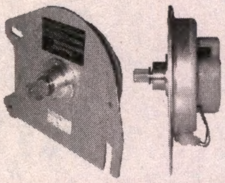
Serial Port Isolated I/O Controller



Kit provides eight relay outputs capable of switching 4 amps at mains voltages and four optically isolated digital inputs. Can be used in a variety of control and sensing applications including load switching, external switch input sensing, contact closure and external voltage sensing. Programmed via a computer serial port, it is compatible with ANY computer & operating system. After programming, PC can be disconnected. Serial cable can be up to 35m long, allowing 'remote' control. User can easily write batch file programs to control the kit using simple text commands. NO special software required – uses any terminal emulator program (built into Windows). All components provided including a plastic case with pre-punched and silk screened front/rear panels to give a professional and attractive finish (see photo).

Order Ref	Description	inc. VAT
3108KT	Serial Port Isolated I/O Controller Kit	**£54.95**
AS3108	Assembled Serial Port Isolated I/O Controller	**£64.95**

Credit Card Sales: 0871 717 7168

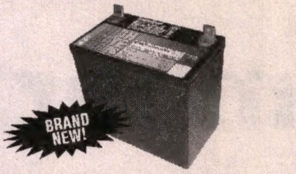


80-173 12V DC motor, flat style, 3000 RPM, 18 NCM torque, draws 5 Amps, reversible, 24 toothed gear. Ideal for robot wars, etc. Dimensions 152mm diameter x 80mm including spindle and gear. Very good quality mounted on a fixing bracket. Some sort of speed counting circuitry on rear. **Bargain at just £19.95**

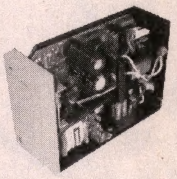
80-175 In-line RCD protected powerbreaker. Maximum load 10A @ 250V AC. Reset and test buttons. IEC plug for mains input with an IEC socket on a 1m long lead. These usually sell for around £36.00. **Our price £5.00**

80-083 CR2025 lithium, 3V coin cell. 20mm diameter x 2.5mm thick. Branded Sony. **Pack of 25 for £7.50; Pack of 100 for £25.00.** *Our normal price individually is £1.00 each!!!*

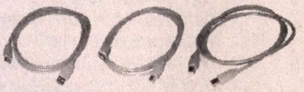
56-155 KBPC3501 bridge rectifier. 100V, 35Amp. **£2.50 each**



80-176 12V, 50Ah, gel type lead acid battery. Made by Dynasty High Rate Series, 200 WPC. Model No. UPS12-200. 230 x 140 x 225mm. Brand new. *Please note that there is no extra carriage charge when purchasing this item.* **Only £25.00**



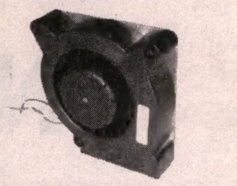
80-132 Switch mode PSU. Nice little unit. Model No. BM43024. Input 120V AC or 240V AC. Output +5V @ 2.5A and +12V @ 2A, 36.5W. Semi-cased with mains IEC filter and switch. **£3.95**



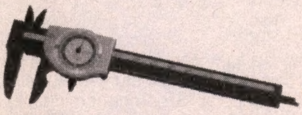
38-428 USB lead, 2m long, 'A' plug to 'A' plug. **£2.95**

38-429 USB lead, 2m long, 'A' plug to 'B' plug. **£2.95**

38-430 USB lead, 2m long, 'B' plug to 'B' plug. **£2.95**



80-135 Flat pack fan, 12V DC. Made by Papst. Air flows around the blades and out the side to produce a strong air flow. Excellent for cooling down in crowded enclosures. 121 x 121 x 37mm. Ex-equipment but in full working order and excellent condition. These are normally over £25.00 new. **Our price just £5.50**



42-337 Plastic construction metric dial vernier. Reads 0-100mm. Outside, inside, depth and step measurements. Has a locking device and comes supplied in a neat case. **£7.95**

48-140 PVC electrical tape, 19mm wide x 0.15mm thick x 33 metres long. Flame retardant, BS3924. **75p**

48-259 Ferrite rod with 1 x tuning coil. 140mm long x 10mm diameter. **£1.75**

80-046 Electronic digital caliper for both imperial (0-6 inches) and metric (0-150mm). Accuracy +/-0.001". Simple touch button facility to change from metric to imperial (and vice versa). On/off and zero button, inside and outside measuring plus locking screw to hold measurement. Uses a standard watch battery (included). Metal construction. Supplied in a neat plastic storage case. **Special price of £34.95**

56-149 Fork and ring crimp connectors pack. Consists of 5 x 5mm blue fork, 5 x 5mm yellow fork, 5 x 5mm red fork, 5 x 5mm blue ring, 5 x 5mm yellow ring and 5 x 5mm red ring. **Pack of 30 £1.00**

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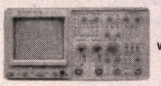

TEKTRONIX 2445A
4-ch 150MHz delay,, cursors etc. Supplied with 2 Tektronix probes.
ONLY **£425**

TEKTRONIX 2232 Digital Storage Scope. Dual Trace, 100MHz, 100M/S with probes	£525
H.P. 54501A Dig. Oscilloscope, 100MHz 4-Ch	£425
H.P. 3312A Function Gen., 0·1Hz-13MHz, AM/FM Sweep/Tri/Gate/Brst etc.	£300
FARNELL Dual PSU XA35-2T, 0-35V, 0-2A, Twice QMD, l.c.d. Display	£180
CIRRUS CRL254 Sound Level Meter with Calibrator 80-120dB, LEQ	£150
FARNELL AMM255 Automatic Mo Meter, 1·5MHz-2GHz, unused	£300
FARNELL DSG1 Low Frequency Syn Sig. Gen., 0·001Hz-99·99kHz, low distortion, TTL/Square/Pulse Outputs etc.	£95
FLUKE 8060A Handheld True RMS, DMM, 4½ digit	As new **£150,** used **£95**
BECKMAN HD110 Handheld 3½ digit DMM, 28 ranges, with battery, leads and carrying case	£40

H.P. 3310A Function Gen., 0·005Hz-5MHz, Sine/Sq/Tri/Ramp/Pulse	£125
FARNELL LFM4 Sine/Sq Oscillator, 10Hz-1MHz, low distortion, TTL output, Amplitude Meter	£125
H.P. 545A Logic Probe with 546A Logic Pulser and 547A Current Tracer	£90
FLUKE 77 Multimeter, 3½-digit, handheld	£60
FLUKE 77 Series 11	£70
HEME 1000 L.C.D. Clamp Meter, 00-1000A, in carrying case	£60

BLACK STAR ORION PAL/TV Colour Pattern Generator	from £75-£125
THURLBY/THANDER TG210 Function Generator, 0·002Hz-2MHz, TTL etc.	£80-£95
THURLBY THANDAR P.S.U. PL320QMD, 0V-32V, 0A-2A Twice (late colours)	£200

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High Quality 5·5 Digit Bench Multimeter
True RMS/4 wire Res/Current Converter/IEEE
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50kHz-30MHz
L.E.D. Display. Basically working.
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Power Supply HPS3010, 0-30V, 0-10A	£140
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FARNELL L30-1 0-30V, 0-1A	£60

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Dual trace, 12MHz TV, coupling .ONLY **£75**

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10Hz-1MHz. ONLY **£75**

OSCILLOSCOPES

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TEKTRONIX TDS320 dual trace, 100MHz, 500M/S	£1200
TEKTRONIX TDS310 dual trace, 50MHz, 200M/S	£950
LECROY 9400A dual trace, 175MHz, 5G/S	£750
HITACHI VC6523, d/trace, 20MHz, 20M/S, delay etc.	Unused £500
PHILIPS PM3092 2+2-ch., 200MHz, delay etc., £800 as new	£950
PHILIPS PM3082 2+2-ch., 100MHz, delay etc., £700 as new	£800
TEKTRONIX TAS465 dual trace, 100MHz, delay etc.	£750
TEKTRONIX 2465B 4-ch., 400MHz, delay cursors etc	£1500
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TEKTRONIX 468 Dig. Storage, dual trace, 100MHz, delay	£450
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PHILIPS PM3217 dual trace, 50MHz delay	£200-£250
GOULD OS1100 dual trace, 30MHz delay	£125
HAMEG HM303.6 dual trace, 35MHz component tester as new	£240
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R&S APN62 Synth, 1Hz-260kHz sig. gen., balanced/unbalanced output, l.c.d. display	£425
PHILIPS PM5328 sig gen, 100kHz-180MHz with 200MHz, freq. counter, IEEE	£550
RACAL 9081 Synth AM/FM sig g en, 5kHz-1024MHz	£250
H.P. 3325A Synth function gen, 21MHz	£600
MARCONI 6500 Amplitude Analyser	£1500
H.P. 4192A Impedance Analyser	£5000
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RACAL Counter type 1999 2·6GHz	£500
H.P. Counter type 53131A 3GHz	£850
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BLACK STAR JUPITOR 2010 Func. Gen, 0·2Hz-2MHz with frequency counter	£140
H.P. 8116A Pulse Generator, 1mH-50MHz	£1950
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H.P. 8443 Tracking Gen/Counter, 110MHz	£250
H.P. 8444 OPT 059	£750
B&K 2033R Signal Analyser	£650
H.P. 8754A Network Analyser, 4MHz-1300MHz	£1250
H.P. 3557A Network Analyser, 5Hz-200MHz	£3000
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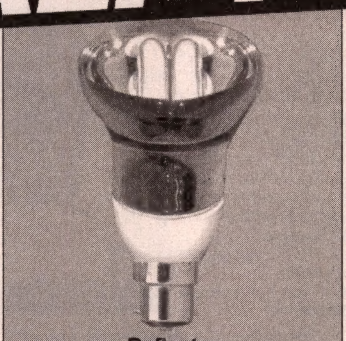
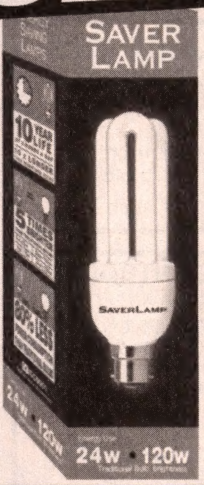
Bayonet Fitting

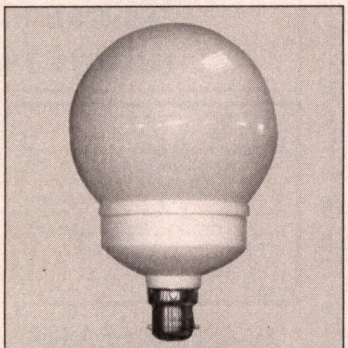
Energy used	Bright -ness	Price Each	Six Pack	Each	FROM
25w	125w	£11.99	£35.97	£6.00	£6



Reflector
Bayonet Fitting

Energy used	Bright -ness	Price Each	Six Pack	Each	FROM
23w	110w	£9.99	£29.97	£5.00	£4
11w	55w	£7.99	£23.97	£4.00	



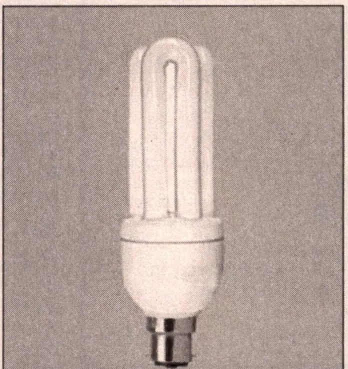


Large Globe
Bayonet Fitting

Energy used	Bright -ness	Price Each	Six Pack	Each	FROM
24w	120w	£8.99	£26.97	£4.50	£4.50

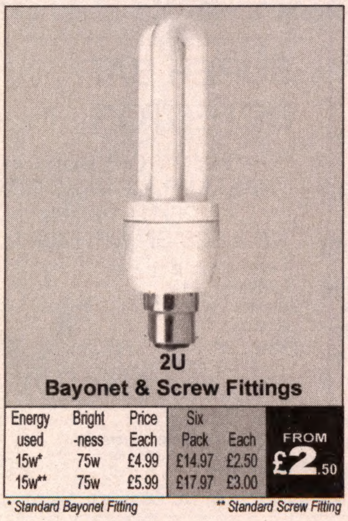
Traditional Shape
Bayonet Fitting

Energy used	Bright -ness	Price Each	Six Pack	Each	FROM
13w	65w	£6.99	£20.97	£3.50	£3
9w	45w	£5.99	£17.97	£3.00	



3U
Bayonet Fitting

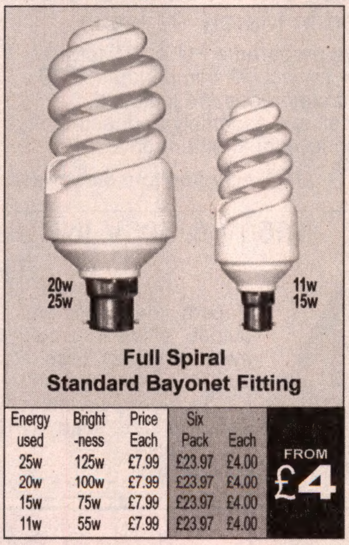
Energy used	Bright -ness	Price Each	Six Pack	Each	FROM
24w	120w	£7.99	£23.97	£4.00	£4



2U
Bayonet & Screw Fittings

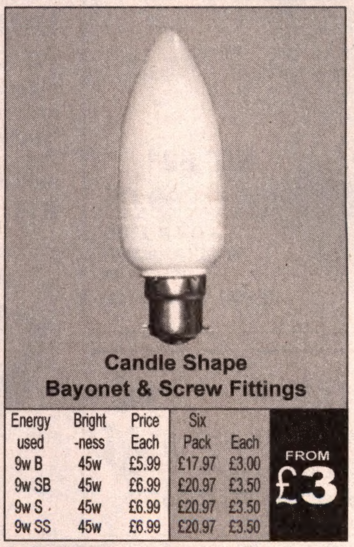
Energy used	Bright -ness	Price Each	Six Pack	Each	FROM
15w*	75w	£4.99	£14.97	£2.50	£2.50
15w**	75w	£5.99	£17.97	£3.00	

* Standard Bayonet Fitting ** Standard Screw Fitting



Full Spiral
Standard Bayonet Fitting

Energy used	Bright -ness	Price Each	Six Pack	Each	FROM
25w	125w	£7.99	£23.97	£4.00	£4
20w	100w	£7.99	£23.97	£4.00	
15w	75w	£7.99	£23.97	£4.00	
11w	55w	£7.99	£23.97	£4.00	



Candle Shape
Bayonet & Screw Fittings

Energy used	Bright -ness	Price Each	Six Pack	Each	FROM
9w B	45w	£5.99	£17.97	£3.00	£3
9w SB	45w	£6.99	£20.97	£3.50	
9w S	45w	£6.99	£20.97	£3.50	
9w SS	45w	£6.99	£20.97	£3.50	

B = Standard Bayonet
SB = Small Bayonet
S = Standard Screw
SS = Small Screw

HOW TO ORDER:

On the Web: Visit www.ultimalamps.com

By Phone: Using your credit card or switch card number. Our lines are open 9am - 5.30pm, Monday to Friday and from 10am - 1pm on Sundays.

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Tel: 01279 821222 Fax: 01279 821300

Email: sales@ultimalamps.com

All Prices Include VAT

(Ultima Lamps is a division of Ultima Networks PLC)

www.ultimalamps.com

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EPE PROJECT PICS

Programmed PICs for *EPE Projects
12C508/9 – £3.90; 16F627/8 – £4.90
16C84/16F84/16C71 – £5.90
16F876/877 – £10.00
All inc. VAT and Postage

(*Some projects are copyright)

EPE MICROCONTROLLER P.I. TREASURE HUNTER

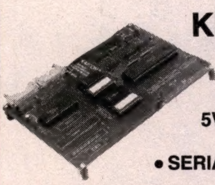
The latest MAGENTA DESIGN – highly stable & sensitive – with I.C. control of all timing functions and advanced pulse separation techniques.

- High stability drift cancelling
- Easy to build & use
- No ground effect, works in seawater
- Detects gold, silver, ferrous & non-ferrous metals
- Efficient quartz controlled microcontroller pulse generation.
- Full kit with headphones & all hardware

KIT 847 ....£63.95

68000 DEVELOPMENT TRAINING KIT

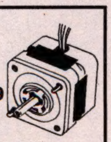
- NEW PCB DESIGN
- 8MHz 68000 16-BIT BUS
- MANUAL AND SOFTWARE
- 2 SERIAL PORTS
- PIT AND I/O PORT OPTIONS
- 12C PORT OPTIONS



KIT 621
£99.95

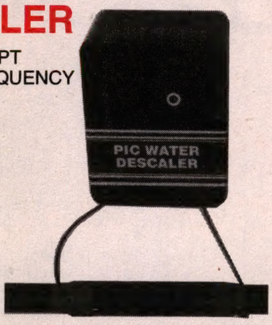
- **ON BOARD 5V REGULATOR**
- **PSU £6.99**
- **SERIAL LEAD £3.99**

Stepping Motors



MD100..Std 100 step..£9.99
MD200...200 step...£12.99
MD24...Large 200 step...£22.95

PIC PIPE DESCALER



- SIMPLE TO BUILD
- HIGH POWER OUTPUT
- AUDIO & VISUAL MONITORING
- SWEPT FREQUENCY

An affordable circuit which sweeps the incoming water supply with variable frequency electromagnetic signals. May reduce scale formation, dissolve existing scale and improve lathering ability by altering the way salts in the water behave.
Kit includes case, P.C.B., coupling coil and all components.
High coil current ensures maximum effect. L.E.D. monitor.

KIT 868 .... £22.95 **POWER UNIT......£3.99**

MICRO PEsT SCARER

Our latest design – The ultimate scarer for the garden. Uses special microchip to give random delay and pulse time. Easy to build reliable circuit. Keeps pets/pests away from newly sown areas, play areas, etc. uses power source from 9 to 24 volts.

- **RANDOM PULSES**
- **HIGH POWER**
- **DUAL OPTION**

Plug-in power supply £4.99

KIT 867.............................£19.99
KIT + SLAVE UNIT...................£32.50

WINDICATOR

A novel wind speed indicator with LED readout. Kit comes complete with sensor cups, and weatherproof sensing head. Mains power unit £5.99 extra.

KIT 856.............................£28.00

★ TENS UNIT ★

DUAL OUTPUT TENS UNIT

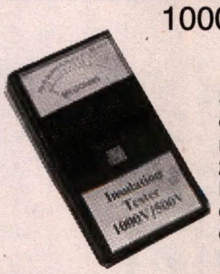
As featured in March '97 issue.

Set of 4 spare electrodes £6.50

Magenta have prepared a FULL KIT for this. excellent new project. All components, PCB, hardware and electrodes are included.
Designed for simple assembly and testing and providing high level dual output drive.

KIT 866. . Full kit including four electrodes £32.90

1000V & 500V INSULATION TESTER



Superb new design. Regulated output, efficient circuit. Dual-scale meter, compact case. Reads up to 200 Megohms.
Kit includes wound coil, cut-out case, meter scale, PCB & ALL components.

KIT 848.............£32.95

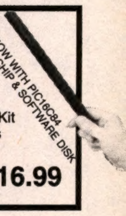
EPE TEACH-IN 2000

Full set of top quality *NEW* components for this educational series. All parts as specified by *EPE*. Kit includes breadboard, wire, croc clips, pins and all components for experiments, as listed in introduction to Part 1.
**Batteries and tools not included.*

TEACH-IN 2000 -

KIT 879 £44.95
MULTIMETER £14.45

SPACEWRITER


NOW WITH PIC16C84 EEPROM CHIP & SOFTWARE DISK

An innovative and exciting project. Wave the wand through the air and your message appears. Programmable to hold any message up to 16 digits long. Comes pre-loaded with "MERRY XMAS". Kit includes PCB, all components & tube plus instructions for message loading.

KIT 849 ....£16.99

12V EPROM ERASER

A safe low cost eraser for up to 4 EPROMS at a time in less than 20 minutes. Operates from a 12V supply (400mA). Used extensively for mobile work - updating equipment in the field etc. Also in educational situations where mains supplies are not allowed. Safety interlock prevents contact with UV.

KIT 790 ....£29.90

SUPER BAT DETECTOR

1 WATT O/P, BUILT IN
SPEAKER, COMPACT CASE
20kHz-140kHz
NEW DESIGN WITH 40kHz MIC.

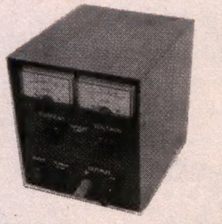
A new circuit using a 'full-bridge' audio amplifier i.c., internal speaker, *and* headphone/tape socket. The latest sensitive transducer, and 'double balanced mixer' give a stable, high performance superheterodyne design.

KIT 861 ....£24.99

ALSO AVAILABLE Built & Tested. . . £39.99

MOSFET MkII VARIABLE BENCH POWER SUPPLY 0-25V 2·5A

Based on our Mk1 design and preserving all the features, but now with switching pre-regulator for much higher efficiency. Panel meters indicate Volts and Amps. Fully variable down to zero. Toroidal mains transformer. Kit includes punched and printed case and all parts. As featured in April 1994 *EPE*. An essential piece of equipment.



Kit No. 845 ....£64.95

ULTRASONIC PEsT SCARER

Keep pets/pests away from newly sown areas, fruit, vegetable and flower beds, children's play areas, patios etc. This project produces intense pulses of ultrasound which deter visiting animals.

- KIT INCLUDES ALL COMPONENTS, PCB & CASE
- EFFICIENT 100V TRANSDUCER OUTPUT
- COMPLETELY INAUDIBLE TO HUMANS
- UP TO 4 METRES RANGE
- LOW CURRENT DRAIN

KIT 812...............................£15.00

SIMPLE PIC PROGRAMMER

KIT 857... £12.99

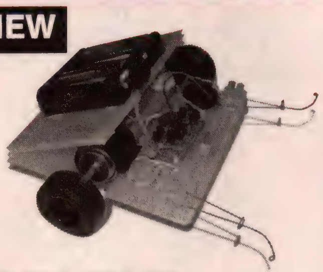
Includes PIC16F84 chip disk, lead, plug, p.c.b., all components and instructions

Extra 16F84 chips £3.84
Power Supply £3.99

MAGENTA BRAINIBOT I & II

NEW

- Full kit with ALL hardware and electronics
- As featured in *EPE* Feb '03 – KIT 910
- Seeks light, beeps, avoids obstacles
- Spins and reverses when 'cornered'
- Uses 8-pin PIC
- ALSO KIT 911 – As 910 *PLUS* programmable from PC serial port – leads and software CD provided



KIT 910 £16.99 **KIT 911 £24.99**

PIC 16F84 MAINS POWER 4-CHANNEL CONTROLLER & LIGHT CHASER

- ZERO VOLT SWITCHING
- OPTO ISOLATED 5 Amp
- 12 KEYPAD CONTROL
- HARD-FIRED TRIACS
- WITH SOURCE CODE
- SPEED & DIMMING POT.
- EASILY PROGRAMMED

Kit 855 £39.95

PIC 16F84 LCD DISPLAY DRIVER

INCLUDES 1-PIC16F84 WITH DEMO PROGRAM SOFTWARE DISK, PCB, INSTRUCTIONS AND 16-CHARACTER 2-LINE

LCD DISPLAY

Kit 860 £19.99

Power Supply £3.99

FULL PROGRAM SOURCE CODE SUPPLIED – DEVELOP YOUR OWN APPLICATION!

Another super PIC project from Magenta. Supplied with PCB, industry standard 2-LINE × 16-character display, data, all components, and software to include in your own programs. Ideal development base for meters, terminals, calculators, counters, timers – Just waiting for your application!

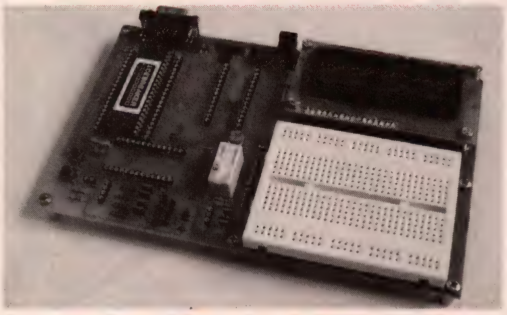
8-CHANNEL DATA LOGGER

NEW!

As featured in Aug./Sept. '99 *EPE*. Full kit with Magenta redesigned PCB – LCD fits directly on board. Use as Data Logger *or* as a test bed for many other 16F877 projects. Kit includes programmed chip, 8 EEPROMs, PCB, case and all components.

KIT 877 £49.95 inc. 8 × 256K EEPROMS

ICEBREAKER



PIC Real Time In-Circuit Emulator

- Icebreaker uses PIC16F877 in circuit debugger
- Links to Standard PC **Serial** Port (lead supplied)
- Windows™ (95+) Software included
- Works with MPASM and MPLAB Microchip software
- 16 x 2 L.C.D., Breadboard, Relay, I/O devices and patch leads supplied

As featured in March '00 *EPE*. Ideal for beginners AND advanced users.
Programs can be written, assembled, downloaded into the microcontroller and run at full speed (up to 20MHz), or one step at a time.
Full emulation means that all I/O ports respond exactly and immediately, reading and driving external hardware.
Features include: Reset; Halt on external pulse; Set Breakpoint; Examine and Change registers, EEPROM and program memory; Load program, Single Step with display of Status, W register, Program counter, and user selected 'Watch Window' registers.

KIT 900 . . . £34.99

POWER SUPPLY **£3.99** STEPPING MOTOR 100 STEP **£9.99**

EPE PIC TOOLKIT 3

NEW

- THE LATEST TOOLKIT BOARD – 8, 18, 28 AND 40-PIN CHIPS
- MAGENTA DESIGNED P.C.B. WITH COMPONENT LAYOUT AND EXTRAS
- L.C.D., BREADBOARD AND PIC CHIP INCLUDED
- ALL TOP QUALITY COMPONENTS AND SOFTWARE SUPPLIED

KIT 880 . . . £34.99 with 16F84 . . . £39.99 with 16F877

PIC TOOLKIT V2

- SUPER UPGRADE FROM V1
- 18, 28 AND 40-PIN CHIPS
- READ, WRITE, ASSEMBLE & DISASSEMBLE PICS
- SIMPLE POWER SUPPLY OPTIONS 5V-20V
- ALL SWITCHING UNDER SOFTWARE CONTROL
- MAGENTA DESIGNED PCB HAS TERMINAL PINS AND OSCILLATOR CONNECTIONS FOR ALL CHIPS
- INCLUDES SOFTWARE AND PIC CHIP

KIT 878 . . . £22.99 with 16F84 . . . £29.99 with 16F877

EPE PIC Tutorial

At last! A Real, Practical, Hands-On Series

- **Learn Programming from scratch using PIC16F84**
- **Start by lighting l.e.d.s and do 30 tutorials to Sound Generation, Data Display, and a Security System.**
- **PIC TUTOR Board with Switches, l.e.d.s, and on board programmer**

PIC TUTOR BOARD KIT

Includes: PIC16F84 Chip, TOP Quality PCB printed with Component Layout and all components* (*not ZIF Socket or Displays). Included with the Magenta Kit is a disk with Test and Demonstration routines.

KIT 870 .... £27.95, Built & Tested £42.95

Optional: **Power Supply – £3.99, ZIF Socket – £9.99**

LCD Display .... £7.99 LED Display £6.99

Reprints Mar/Apr/May 98 – **£3.00 set 3**

SUPER PIC PROGRAMMER

- READS, PROGRAMS, AND VERIFIES
- WINDOWS™ SOFTWARE
- PIC16C AND 16F – 6X, 7X, AND 8X
- USES ANY PC PARALLEL PORT
- USES STANDARD MICROCHIP
- HEX FILES
- OPTIONAL DISASSEMBLER SOFTWARE (EXTRA)
- PCB, LEAD, ALL COMPONENTS, TURNED-PIN SOCKETS FOR 18, 28, AND 40 PIN ICs

- SEND FOR DETAILED INFORMATION – A SUPERB PRODUCT AT AN UNBEATABLE LOW PRICE.

Kit 862 £29.99

Power Supply £3.99

DISASSEMBLER SOFTWARE £11.75

PIC STEPPING MOTOR DRIVER

INCLUDES PCB, PIC16F84 WITH DEMO PROGRAM, SOFTWARE DISC, INSTRUCTIONS AND MOTOR.

Kit 863 £18.99

FULL SOURCE CODE SUPPLIED ALSO USE FOR DRIVING OTHER POWER DEVICES e.g. SOLENOIDS

Another Magenta PIC project. Drives any 4-phase unipolar motor – up to 24V and 1A. Kit includes all components and 48 step motor. Chip is pre-programmed with demo software, then write your own, and re-program the same chip! Circuit accepts inputs from switches etc and drives motor in response. Also runs standard demo sequence from memory.

MAGENTA

All prices include VAT. Add **£3.00** p&p. Next day **£6.99**

Tel: 01283 565435 Fax: 01283 546932 E-mail: sales@magenta2000.co.uk

042003

ELECTRONIC COMPONENTS

Station Road, Cullercoats,
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Prices Exclude Vat @17½%.
UK Carriage £1.50 (less than 1kg)
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Cheques / Postal orders payable to
ESR Electronic Components.
PLEASE ADD CARRIAGE & VAT TO ALL ORDERS

See Next / Last Months Ad. for ELECTRONIC COMPONENTS

PCB Production - Processing Equipment

We carry a large range of the photographic & chemical processing equipment for PCB production, a full list with full technical specifications is available in our catalogue or vist our web site.

UV Exposure units

2 x 8W Tubes, 6 min timer
229 x 159mm working area
Model 332-002 £88.78
4 x 15W Tubes, 7½ min timer
330 x 260mm working area
Model 332-004 £194.51

Chemical Processing

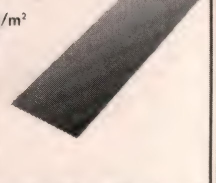
Low cost plastic tray £1.50
Process tanks feature electrically operated pumps and/or heaters with thermostat control, suitable for boards upto 320 x 260mm.
Universal Tank with heater
Model 333-007 £161.60
Bubble etch Tank with heater & bubble pump.
Model 333-004 £198.50

Any of these items, carriage £5.50

PCB Production - Laminates

Copper clad - paper

Single sided low cost paper composite board



100 × 160mm Board	£0.44
100 × 220mm Board	£0.62
160 x 233mm Board	£1.02
220 x 233mm Board	£1.40
8″ x 12″ Board	£1.70

Copper clad - glass fibre

Single & Double 1.6mm 305g/m²

100 × 160mm Single	£0.85
100 × 220mm Single	£1.18
160 x 233mm Single	£2.29
220 x 233mm Single	£2.88
8″ x 12″ Single	£3.44
100 × 160mm Double	£0.88
100 × 220mm Double	£1.25
160 x 233mm Double	£2.30
220 x 233mm Double	£2.90
8″ x 12″ Double	£3.22

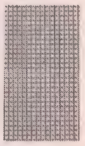
Photoresist Coated

1.6mm 35 micron Pre-coated with a high quality photoresist layer. Available in low cost paper composite or Glass fibre, Single & Double sided. Other sizes also available.

	Paper		Glass Fibre	
Size	Single	Double	Single	Double
4 × 6″	£1.47	£1.82	£1.89	£2.17
6 x 12″	£4.20	£5.04	£5.60	£6.23
9 x 12″	£6.30	£7.70	£8.40	£9.38
10 x 12″	£8.19	£10.01	£10.78	£11.83
12 x 12″	£8.26	£10.08	£10.99	£12.25
100 x 160mm			£2.38	£2.66
203 x 114mm			£3.01	£3.43
220 x 100mm			£3.08	£3.71
233 x 160mm			£4.83	£5.32
233 x 220mm			£6.83	£7.70

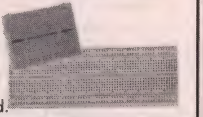
PCB Production - Development

0.1″ Copper Stripboard



Size	Tracks/Holes	
25 x 64mm	9T / 25H	£0.24
64 x 95mm	24T / 37H	£0.87
95 × 127mm	36T / 50H	£1.41
95 × 432mm	36T / 170H	£4.39
100 × 100mm	39T / 38H	£1.40
100 × 160mm	39T / 63H	£1.80
100 × 500mm	39T / 199H	£6.20
119 × 455mm	46T / 179H	£5.40
Stripboard track cutter		£1.99

Solderless Breadboard



Tie Points & Size		Power Rails	
390	81 x 60mm	2	£2.75
840	175 x 67mm	2	£4.86
740	175 x 55mm	1	£4.03
640	175 x 42mm	0	£3.08

Many other sizes available, also jump wires & matrix board.

PCB Production - Tools

Drill Bits

HSS parallel shank bits available in sizes from 0.3mm to 2.0mm

0.3-0.95mm in 0.05mm steps	£0.60ea	£4.00/10
1.0-2.0mm in 0.1mm steps	£0.40ea	£3.60/10

HSS Reduced shank (2.35mm) bit available in sizes from 0.6mm to 1.7mm in 0.1mm steps £0.84ea £7.60/10
Reground Tngsten carbide reduced shank (3.2mm) available in sizes from 0.6 to 1.6mm in 0.1mm steps £1.90

Drilling Machines

Expo reliant 12V drill, 3.8mm capacity, 8400rpm £12.78

Minicraft MX1 230V, 8000 - 21000rpm with chuck & collet.
Model EPE270-390
Normal price £48.51

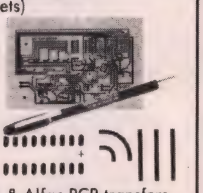
** **SPECIAL OFFER PRICE £31.02** **

PCB Production - Chemicals

100ml	Aerosol Photoresist spray, covers 2m²	£4.25
50g	Powder developer, makes 1lt	£1.09
500g	Powder developer, makes 10lt	£7.08
250g	Ferric Chloride Pellets, makes 500ml	£1.68
500g	Ferric Chloride Pellets, makes 1lt	£3.04
2.5kg	Ferric Chloride Pellets, makes 5lt	£9.84
1.1kg	Clear Fine etch crystals, makes 5lt	£17.58
90g	Tin Plating Powder, makes 1lt	£11.58
200ml	Aerosol Flux spray	£3.41
110ml	Aerosol PCB Laquer spray	£3.63

PCB Production - Drafting Materials

A4 Artwork Film (per 10 sheets)



Clear Manual Film	£1.25
Clear Laser Film	£1.75
White HQ Laser Film	£4.62

Etch Resist Pens

"Dalo" Pen	£2.70
"Staedtler" Fine Pen	£0.88

Etch Resist Transfers

Seno mixed DIL pads	£2.24
Seno mixed Rnd pads	£2.24
Alfac mixed pads	£1.84
Alfac mixed lines	£1.84
Transfer Spatular	£1.25

We carry the full range of Seno & Alfac PCB transfers, see our catalogue for full details.

Servisol Products

Aerosols

200ml	Switch Cleaner	£1.96
200ml	Freezer	£3.97
400ml	Foam Cleanser	£2.13
400ml	Cleaner / lubricant	£2.79
75ml	Vide Head Cleaner	£1.94
200ml	Aero Klene	£2.85
200ml	Aero Duster	£4.66
250ml	Cold Clean	£3.14
200ml	Label remover	£3.52
400ml	Isopropyl alcohol	£3.36

Tubes

25g	Heatsink Compound	£2.60
50g	Silicone grease	£2.50

Magnifying Desk Lamp

A high quality scratch resistant magnifying glass fitted to a balanced swivel arm and desk mount. An integral flourescent tube provides illumination.
Magnification: 3x Lens: 120mmØ
Tube: 22W Daylight simulation.

Model: 028-205 £28.80

Soldering Irons

We carry in stock a wide range of soldering iron and soldering accessories. Irons from 12 to 100 Watts.

15W 240V Low cost	£2.80
20W 240V Basic	£3.74
25W 240V Ceramic	£14.05
30W 240V Basic	£4.68

Desolder Pumps

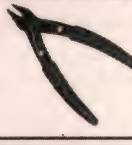
Basic 165 x 18mmØ	£2.85
Antistatic 195mm	£3.92
Antex Mini 198mm	£6.02
Antex Pro 210mm	£10.26

NEW CATALOGUE OUT NOW

available from **www.esr.co.uk**

Tools - Cutters & Strippers

We carry a wide range of specialist tools for the electronics industry including:

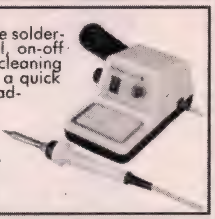


Side Cutters

130mm Low cost	£1.99
115mm Draper	£2.38
115mm Box Jointed	£4.26
145mm Long reach	£3.40
Wire Strippers	
130mm Low cost	£2.30
150mm Draper 5mmØ	£5.86

Soldering Station

A 30W adjustable temperature soldering station with a rotary dial, on-off switch, iron holder and tip cleaning sponge. This station features a quick start circuit for rapid heating, adjustable temperature range of 250 - 450°C, Silicone cable and silicone covered handle.
Supply: 240V, Iron: 240V 30W



Model 167-510 £32.18

Educational Kits

These kits are an ideal way to start you interset in electronics. They freature re-useable components which are attached via springs & wires and easy step by step guides to make a range of exciting projects. The 300-in-1 featurs a breadboard for more complex circuits.

30-in-1	£12.80
50-in-1	£16.80
130-in-1	£32.00
300-in-1	£55.20

Tools - Ratchet Crimping Pliers

High quality ratchet crimping pliers for various terminals including Automotive, Data, Power and Data connections.

Red / Blue / Yellow	£15.80
BNC /TNC RF series	£15.68
RJ11/12 Data Series	£18.97
RJ45 Data Series	£21.20
RJ11/12 & 45 Series	£13.00

CK® Tools Crimp Pliers

Green/Red/Blue	£24.38
Red/Blue/Yellow	£21.42
0.24-2.5mm² crimps	£24.35
0.5-6.0mm² crimps	£24.35
Non insulated crimps	£24.38

Soldering Station

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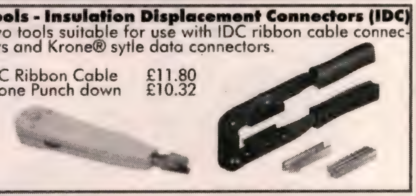

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0-500μA	430Ω
0-1mA	200Ω
0-10mA	2Ω6
0-50mA	1Ω2
0-100mA	0Ω65
0-500mA	0Ω12
0-1A	60mΩ
0-3A	20mΩ
0-5A	12mΩ
0-15A	4mΩ
0-10V	10k
0-15V	15k
0-30V	30k
±50μA	1k9

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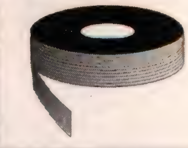
26 Way	£0.26	£13.94
34 Way	£0.34	£18.22
40 Way	£0.40	£21.44
50 Way	£0.50	£26.80
60 Way	£0.64	£33.92



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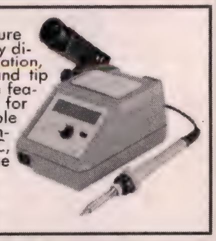
Supply: 240V, Iron: 24V 48W



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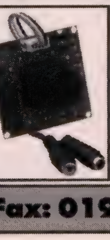

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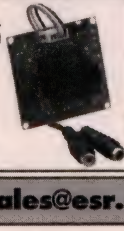

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Pixels: 628 x 582
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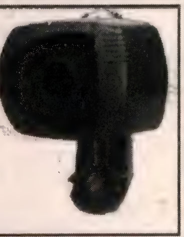

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100 AND COUNTING

Over the years we have learned a lot about the needs of readers – suffice to say that the editorial staff on *EPE* have over 100 years of collective experience in this game – we also try to meet those needs and change with them as interests and technology move on. When microcontrollers came along we were one of the first hobbyist magazines in the world to use them (nearly 11 years ago) and, as they have become more and more popular in hobbyist projects, so we have moved along with them. Back in 1998 we published John Becker's *EPE PIC Tutorial* course and now, five years later, we are unashamedly publishing an updated version.

The original Tutorial has been highly acclaimed and thousands of readers have gained the knowledge to write software and program their own PIC microcontrollers from it. Basically it is still a very sound (possibly the best ever – until now, of course) introduction but, as technology and software have moved on in those five years, and because we can now only supply the original series as a set of photocopies (inconvenient for both us and you, the reader), we have decided it is time for an update.

RESOURCES

To go with the Version 2 series – being published as three 16-page Supplements in the April, May and June issues – we have produced a special *EPE PIC Resources CD-ROM*. This contains not only the V2 Tutorial software for the series, but also the constructional project article (in PDF form) and software for the *PIC Toolkit Mk3* used as the demonstration hardware in the V2 Tutorial (this was originally published in the October and November '01 issues – in case you still have them). We have also included 14 other PIC features and projects (plus software) from past issues of *EPE*, together with four unpublished articles, all on the use and programming of PIC microcontrollers. Whilst we believe the *EPE PIC Resources CD-ROM* will be invaluable to those following the V2 Tutorial, it is not *essential* as the necessary course software is also available for free download from our website, and photocopies of the *PIC Toolkit Mk3* articles are available from our *Back Issues* department, should you need them. Full details on the *PIC Resources CD-ROM*, plus an order form, can be found elsewhere in this issue, it can also be ordered from the shop on our website.

Mike Kenward

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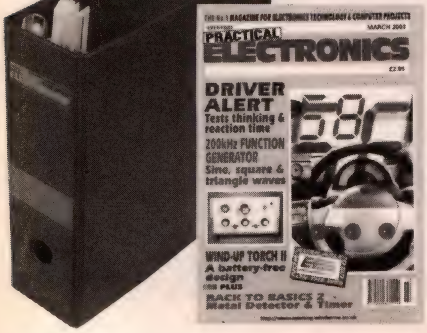

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A number of projects and circuits published in *EPE* employ voltages than can be lethal. **You should not build, test, modify or renovate any item of mains powered equipment unless you fully understand the safety aspects involved and you use an RCD adaptor.**

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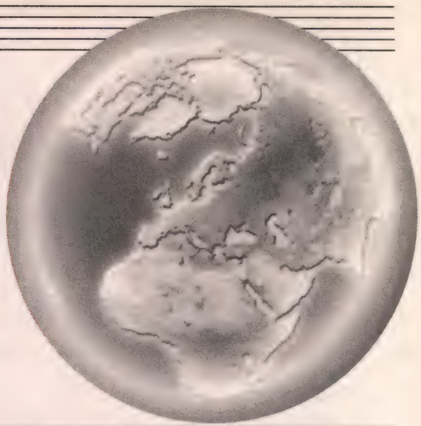
Constructional Project

ATMOSPHERICS MONITOR



BRIAN M. LUCAS

Tune in to the sounds of the heavens in turmoil!

WITH the chaotic weather of recent years, have you given any thought to what's going on up there? It is generally known that you can hear on a domestic radio the electrical activity of lightning when a storm is in progress, with the characteristic large *crack* and *swishing* sound, emanating from the speaker and that's about all.

What if you could hear other sounds over a distance of thousands of miles away, such as *Inter Cloud Discharges, Sliding Whistles, Tweaks, Pings, Chirps, Risers, Chinks, Clicks,* and the exotic *Dawn Chorus?*

"Has this guy lost his marbles?" Well, no, because indeed you can detect and monitor all these sounds from our atmosphere, from the comfort of your home, using little more than a ferrite rod with a wideband amplifier, and piezoelectric sounder – as you can now discover!

WHAT IS THIS ACTIVITY?

There are historical accounts linking the earth's ionosphere sounds that go back to the days of early telephone development over long wires. During 19th Century and First World War use, strange sounds emanating from earphones were noted. They became known as Natural Radio, a product of global lightning, producing on average over 44,000 discharges a day.

The most sought after is the elusive Whistler that produces a sliding note, from around 6kHz down to 300Hz, with a duration of between 0·3 and five seconds. This sound is created when a distant lightning strike on the other side of the earth produces a wide spectrum of electrical noise that becomes ducted into the earth's magnetosphere (magnetic field in space). While radiating outward, it combines with the solar wind's ionising charge to create the dispersed and sliding high to low frequency whistle that can be heard with this design in your hemisphere.

Another rarity is the Dawn Chorus, which sounds like a rookery of birds, combining rising whistles, chirping and warbles, produced through the sun ejecting charged ions that impinge on the earth's magnetosphere, causing the *Northern Lights,* or *Aurora,* seen seasonally from dusk through to dawn in various parts of the northern hemisphere.

Many other short period sounds can be heard like Pings, Hooks, Chirps and Risers; also Chinks and Tweaks. The last two are dampened oscillations from 1·6kHz to 4kHz, throughout the earth's waveguide around the ionosphere's D- and E-layers, 45 to 75 miles above the earth. These create a bell-like resonance that rolls-off sharply around 1·5kHz.

Another sound that can be heard is the Inter-Cloud discharge activity, occurring just as storms build-up, prior to any forked lightning discharges. The excess electrostatic cloud charge reaches its limit, to discharge within the cloud, producing an unusual sound known as "Walking On Broken Glass", variable over a duration of 0·4 to 1·2 seconds.

WHISTLER'S MOTHER?

The experimental years have been long in developing the Atmospherics Monitor described here. The birth of the idea eventually came to maturity as the circuit shown in Fig.1.

The aerial rod and coil assembly, L1, set the radio frequency reception bandwidth. The incoming amplitude modulated signal is initially a.c. coupled to transistor TR1 and op.amp IC1a. Preset VR1 sets the transistor's bias current and thus the half-rail bias voltage (4·5V) for IC1a. Stage gain is principally set to around ×28 by resistors R5 and R6.

The bandwidth of this stage is set by capacitors C2 and C5. The frequency response characteristic at IC1b pin 1 is shown in the top curve in Fig.2. The –1dB knee points are 2·3kHz and 9·1kHz, although as the roll-off continues a greater bandwidth extends until the noise floor is reached at –12·5dB, relating to –63dB or 600μV.

Part of this noise is generated by transistor TR1, even though a low noise BC109C is used. The atmospheric background is alive and kicking just below this

COMPONENTS

ATMOSPHERICS MONITOR

Approx. Cost Guidance Only **£17** *excl. case, batt. & hardware*

Resistors

R1, R10	2k2 (2 off)	R8, R9	220k (2 off)
R2, R16	10k (2 off)	R11	47k
R3	100k	R12	15k
R4	270k	R14, R15	22k (2 off)
R5, R13	1k (2 off)	R17	33k
R6	27k	R18, R19	120k (2 off)
R7	150k	R20	5k6

All 0·25W 2% low-noise metal film

Potentiometers

VR1	47k or 50k min. round preset
VR2	100k rotary carbon

Capacitors

C1, C16	220μ radial elect. 16V (2 off)
C2	10n ceramic disc, 2·5mm pitch
C3, C6, C13, C17	100n ceramic disc 2·5mm pitch (4 off)
C4, C10	2μ2 radial elect, 16V (2 off)
C5, C8	1μ radial elect, 16V (2 off)
C7	220p ceramic disc, 2·5mm pitch
C9	560p ceramic disc, 2·5mm pitch
C11	220n ceramic disc, 2·5mm pitch
C12	3n3 ceramic disc, 2·5mm pitch
C14	820p ceramic disc, 2·5mm pitch
C15	22μ radial elect. 16V

Semiconductors

D1 to D3	1N4148 signal diode (3 off)
TR1, TR2	BC109C *npn* transistor (2 off)
IC1, IC2	LM358 dual op.amp (2 off)

Miscellaneous

L1	ferrite rod, 200mm x 10mm dia., plus 500 turns 40s.w.g. enamelled copper wire
ME1	250μA panel meter
WD1	resonant piezo sounder, 4·6kHz

Stripboard, 13 strips x 35 holes; plastic case to suit (optional); furniture "foot" to fit WD1; plastic tube to mount L1 – see text; 9V PP3 battery and clip; knob for VR2; solder, etc.

See SHOP **TALK** **page**

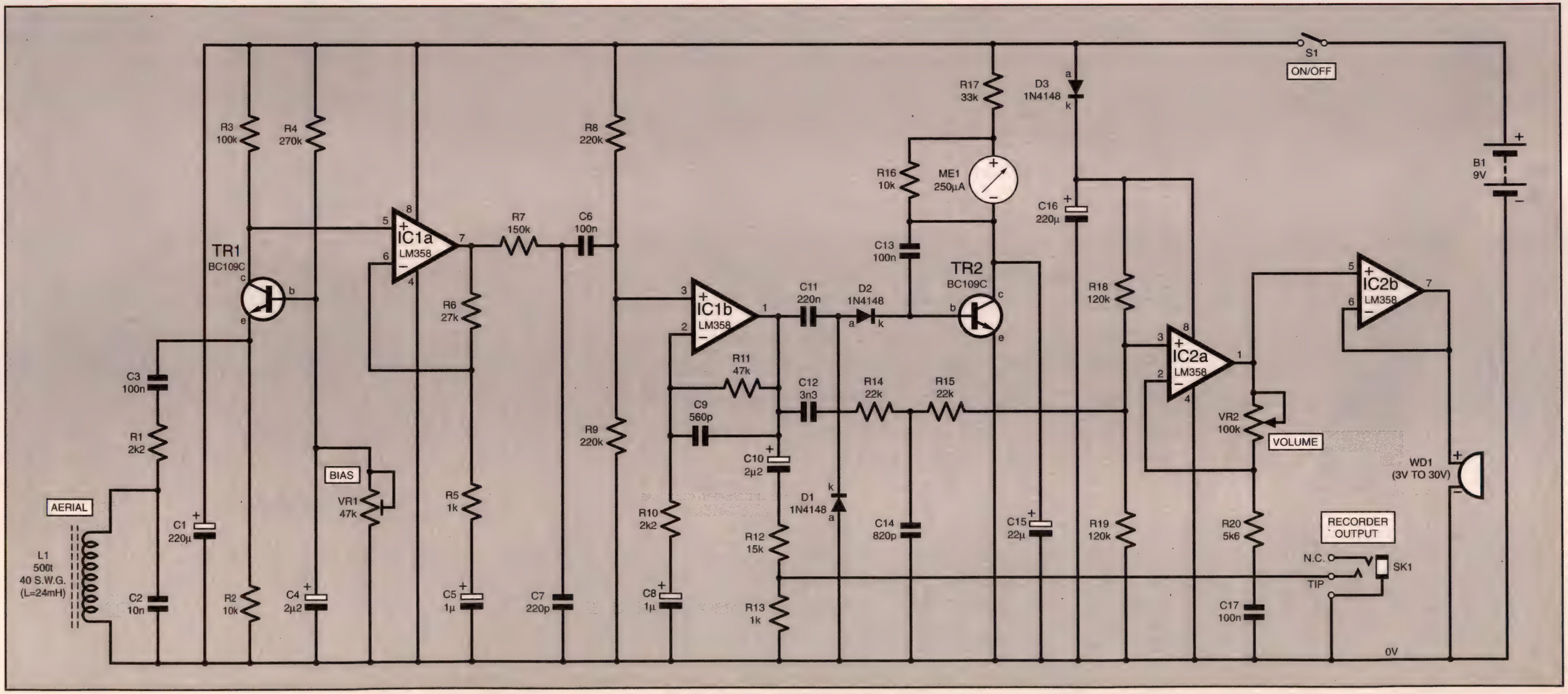


Fig.1. Complete circuit diagram for the Atmospherics Monitor.

level, and the average activity appears between –11dB and –4dB over a range of 1000 miles, but can peak in times of storms to +1dB of short duration electrostatic pulses.

The output from IC1a is a.c. coupled to the second stage, around IC1b, where further gain of about ×22 is given, as set by resistors R10 and R11. Capacitor C9 limits the upper frequency response in order to maintain stability.

The output from IC1b is taken in three directions. The first route is to the stage around transistor TR2. The signal is rectified by diodes D1, D2 and capacitor C13, and then amplified by TR2 to drive the 250μA meter ME1.

This signal activity meter provides weighted readings of atmospheric discharges. On quiet days the meter pointer will deflect to a quarter of its scale, but can change to half or more of full scale readings as inter-cloud activity builds up. Really frenetic activity will produce full scale deflection. On power-up the meter swings to full scale deflection to indicate good battery condition.

The output from IC1b is also a.c. coupled via capacitor C10 and attenuated by resistors R12 and R13. This signal is suitable for feeding to the microphone input of a tape recorder.

Thirdly, the output from IC1b feeds via capacitor C12 and resistors R14 and R15 to the audio gain stage provided by IC2a. The gain is set by potentiometer VR2. The output from IC2a is buffered by unity-gain stage IC2b which drives a resonant piezo sounder having 80dB of gain.

Referring again to Fig.2, the lower graphic curve shows the response at the output of IC2b. It has similar characteristics to the upper curve, but has been given a reduced roll-off at 7·3kHz. This is primarily due to the sounder resonating at 4·6kHz, although not very sharply.

A standard loudspeaker was found to be unsuitable in this application, because the induction between the aerial and speaker would cause feedback when the volume was increased. By using a piezo sounder the output's electromagnetic field is kept exceptionally low.

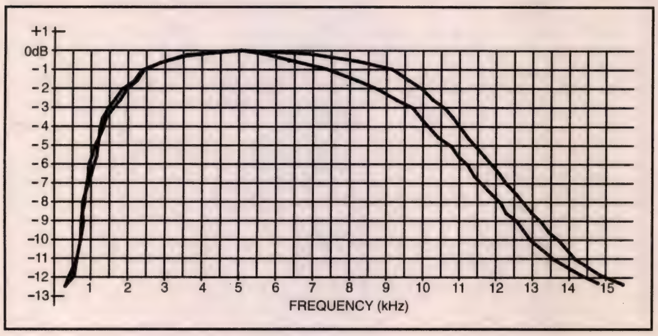


Fig.2. Monitor frequency responses.

In practice, the amplifier output stage's micro eddy currents are the limiting factor, so the overall gain is set such that soft sounds can just be heard above the background noise, without causing signal feedback.

Power for the circuit can be provided by a 9V PP3 battery.

Current consumption is about 2mA maximum. The supply is smoothed by capacitor C1 for the stages up to TR2. For the output stage around IC2, the supply is via diode D3, smoothed by capacitor C16. This is to minimise instability in the rest of the circuit from large electromagnetic pulses.

CONSTRUCTION

The Atmospherics Monitor is constructed on stripboard. The component layout and track cut details are shown in Fig.3. Note that some resistors are mounted vertically. Use sockets for both i.c.s. Assemble in order of ascending component size.

The aerial ferrite rod required should be 200mm long by 10mm diameter. The use of two 100mm rods is permissible, but they

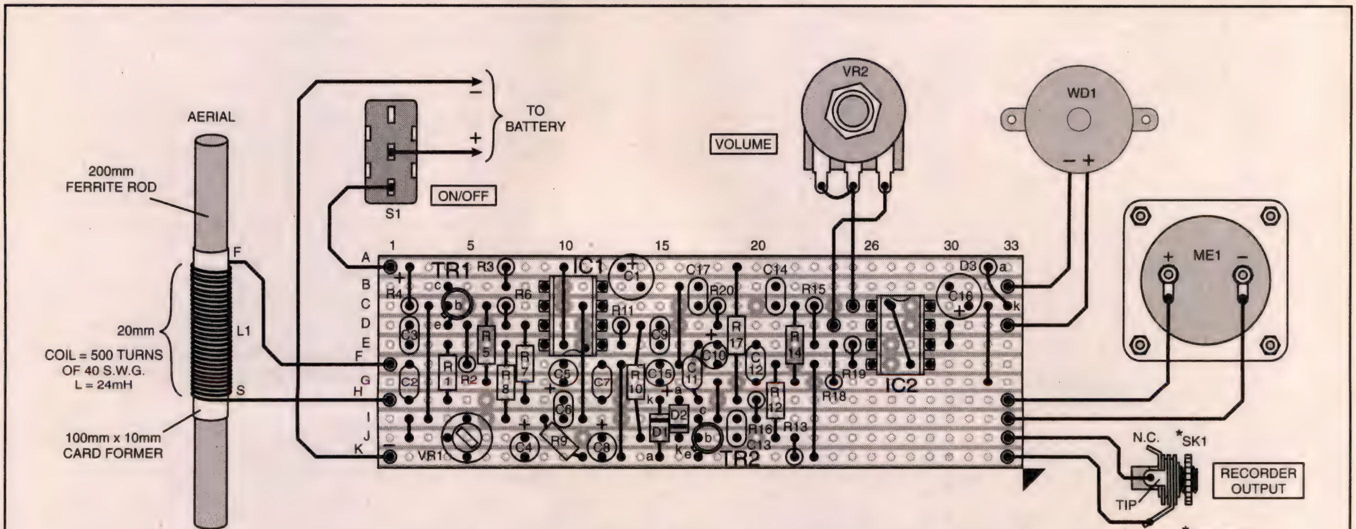
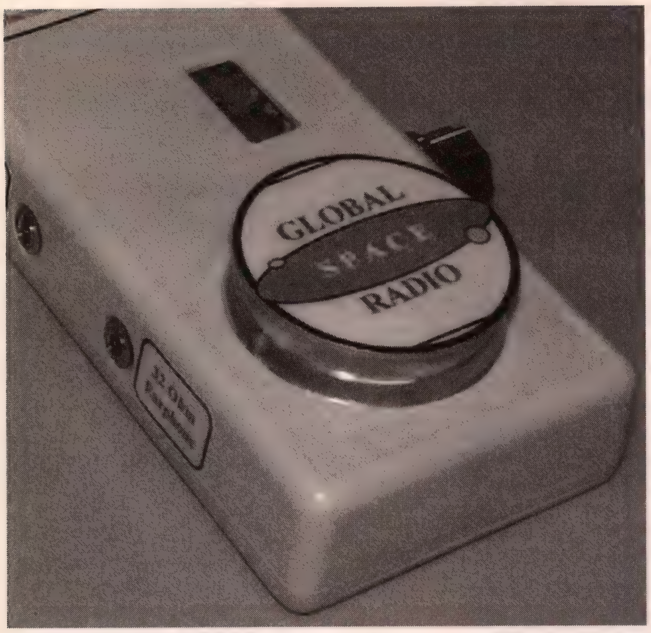


Fig.3. Stripboard component layout, interwiring and details of breaks required in the underside copper tracks.



The translucent "furniture cup" is held in position on the case by the sounder mounting lugs.

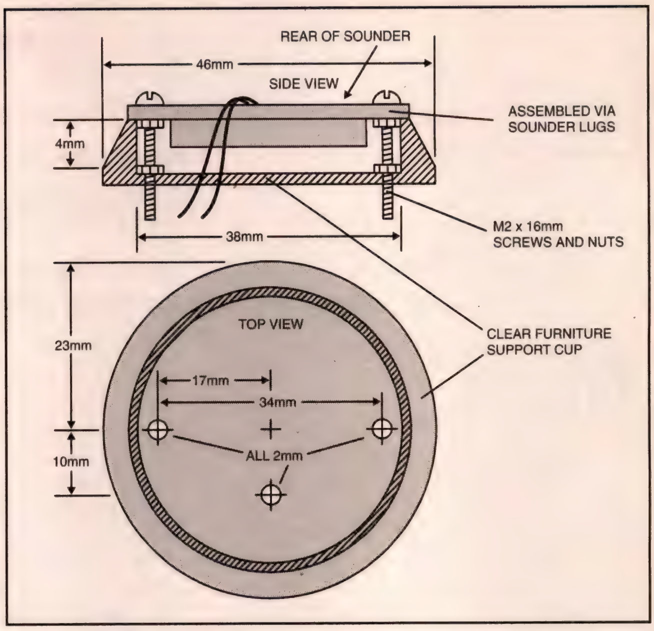

REAR OF SOUNDER
46mm
SIDE VIEW
ASSEMBLED VIA SOUNDER LUGS
4mm
38mm
M2 x 16mm SCREWS AND NUTS
23mm
TOP VIEW
CLEAR FURNITURE SUPPORT CUP
17mm
34mm
ALL 2mm
10mm

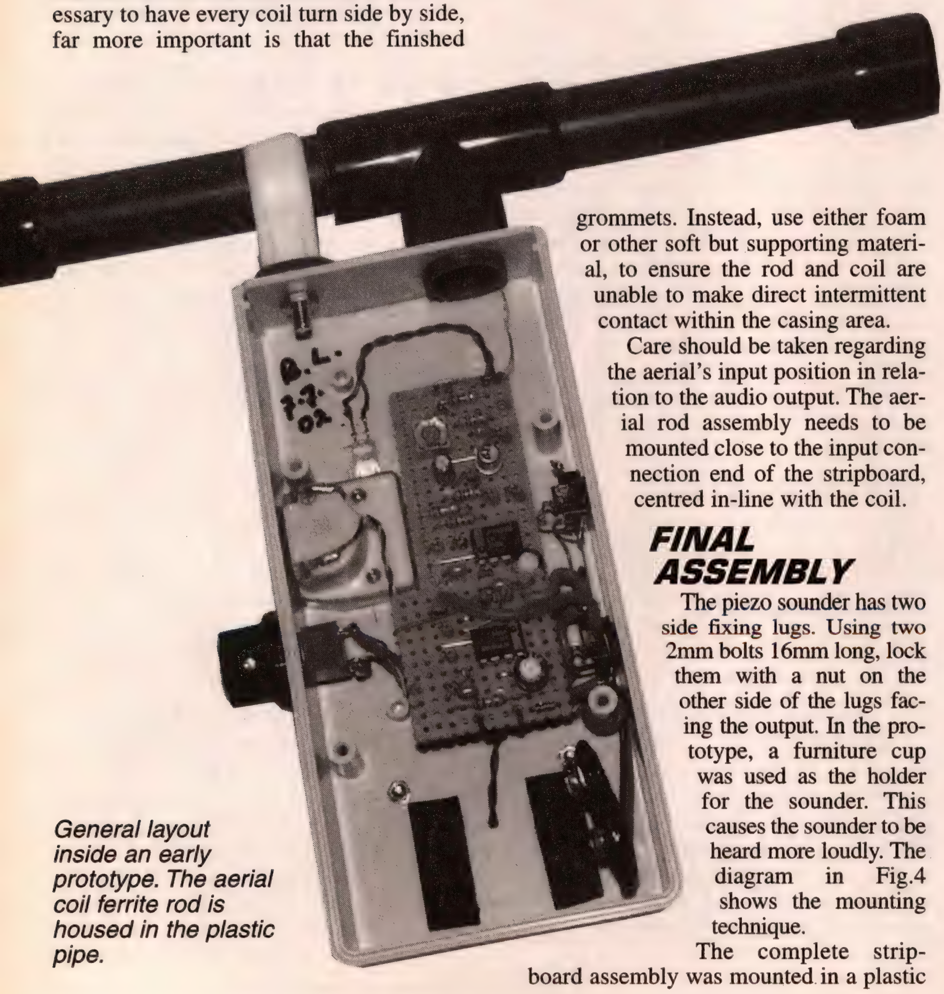
Fig.4. Suggested method of mounting the piezo sounder on the outside of the case.

must be glued end-to-end whilst held under pressure. The coil former should be 100mm in length, formed from thin cardboard into a tube that can be slid tightly over the rod to span its centre.

COIL WINDING AND ASSEMBLY

The coil requires 500 turns of 40s.w.g. enamelled copper wire. This should be wound onto the cardboard former, within a 20mm area, back and forth. It is not necessary to have every coil turn side by side, far more important is that the finished result has an even coil surface, by filling in gaps with turns as an ongoing process. At the last turn, label this wire as the finished over-winding (marked F in Fig.3), for negative 0V connection to the stripboard. The inductance value is roughly 24mH. Insulating tape can be used to secure the coil turns in position, or use glue.

The rod assembly needs supporting onto resilient mounts, but do not use rubber grommets. Instead, use either foam or other soft but supporting material, to ensure the rod and coil are unable to make direct intermittent contact within the casing area.



General layout inside an early prototype. The aerial coil ferrite rod is housed in the plastic pipe.

Care should be taken regarding the aerial's input position in relation to the audio output. The aerial rod assembly needs to be mounted close to the input connection end of the stripboard, centred in-line with the coil.

FINAL ASSEMBLY

The piezo sounder has two side fixing lugs. Using two 2mm bolts 16mm long, lock them with a nut on the other side of the lugs facing the output. In the prototype, a furniture cup was used as the holder for the sounder. This causes the sounder to be heard more loudly. The diagram in Fig.4 shows the mounting technique.

The complete stripboard assembly was mounted in a plastic case measuring 66mm × 38mm × 140mm, with holes drilled as appropriate.

The aerial was enclosed in a plastic plumbing pipe having an internal diameter of approximately 14mm and a total length of 225mm. The tube was cut and inserted into a plastic "T" junction which was pushed into a hole cut into the case and glued in place. The two ends of the pipe were covered by caps of the same diameter. A plastic pipe clip bolted to the case helps to provide further rigidity of the assembly.

Plastics adhesive bonded the aerial assembly attachments, although this should not be applied until after the unit has been proved to be working correctly.

LISTENING TIMES

Atmospheric activity is primarily East to West, so the aerial rod's length should be aligned with this direction. The period between sunrise and midday tends to be quiet for atmospheric activity. However, from midday to late evening, the clouds and thunderstorms build up through heating and convection, particularly in the summer and autumn months. By sunset the atmospheric activity becomes frenetic, and the Pings, Chirps, Clicks, Hooks and Chinks are likely to be heard.

From midnight to sunrise regular Tweaks and Risers might be heard. Dawn Chorus, as its name suggests, can be heard particularly at sunrise, also other times if Aurora activity is high. Whistlers though, require active solar flare ion bursts via ducting conditions, to produce this sound.

Using the unit indoors, you are likely to encounter interference, mainly from television and computer monitors, but also house wiring to a lesser degree. However, by varying the orientation of the aerial, you can null-out very sharply the majority of unwanted hum and other numerous near-field electromagnetic activity radiated within the home.

The best results come when you are monitoring out of doors in the evening night sky. Moreover, this has its own charm, while you ponder the wonder of our world and the universe beyond the stars! ☐

TECHNO-TALK

ANDY EMMERSON

Fibreless Optics

Optical communication works fine in fibres but its performance in free space is not bad either. Andy Emmerson elucidates.

MENTION optical communications and immediately you think of fibre. Whether it's mind-boggling capacity expansion achievements in dense wavelength-division multiplexing, unrepeatered fibres spanning huge distance, or new developments in fibre-to-the-desk, they all serve to keep fibre optics constantly in mind. Marvellous as this may be, fibre is not the only way to go. Optical communication works equally well outside the confines of waveguides, as users of heliographs and smoke signals have known for two thousand years or more.

In most people's minds, though, there's a big difference between "piped" optics and signalling by light in free space. Fibre is futuristic, free space is somehow dated and potentially uncertain. Given the low cost of wired communication and the all-pervasive nature of wireless, apart from in fibres why on earth would anyone wish to send their messages on a beam of light?

Immediacy, cost, security and freedom from irksome regulation is the short answer. Lightwave transmission links can be set up at short notice over a variety of line-of-sight routes – great for broadcasters or companies needing a quick hook-up between two nearby buildings. The true cost is frequently lower than the alternative options and eavesdropping is effectively impossible in many cases. Finally, because no use is made of cables or radio frequencies, there are no costs and delays resulting from licensing problems.

This is true but it is also a simplification. Lightwave communication in free space takes many forms and these in turn have many differing applications.

SHORT RANGE

Currently the highest profile in the world of optical comms must be accorded to the infra-red systems used for extremely short-range data synchronising applications. All kinds of portable computers, palmtops and electronic organisers use infra-red for data exchange, the advantages being infra-red's minimal battery drain and the fact that it does not require additional hardware or cables on the user's system.

According to the Infra-red Data Association, established in 1993 to create and maintain international standards for the hardware and software used in infra-red communication links, infra-red plays an important role in wireless data communication as it suits the use of laptop computers, wireless data communication and other digital equipment such as personal assistants, cameras, mobile telephones and pagers. The Infra-red Data Association (IrDA) 1.1 standard is a maximum data transmission size of 2,048bytes, and a maximum transmission rate of 4Mbits/s, rising to 16Mbit/s in the near future.

Companies in the USA have extended the concept to supply local area networking systems for office use, although these have only a one-metre range, which may be unsuitable in cluttered environments. Some observers argue that the Bluetooth radio-frequency systems will replace infra-red technology although this overlooks its own shortcomings of bandwidth, coexistence problems with other technologies and that fact that Bluetooth has been pre-sold to such an extent that it will have a tough job living up to user expectations. The most likely scenario is peaceful coexistence.

UP, UP AND AWAY

Outdoors in the wild blue yonder optical communication is already established as a powerful technology that is the equal of both microwave radio and fibre-optic cables.

Optical systems work in the infra-red or near infra-red region of light and the easiest way to visualise how they work is to imagine two points interconnected with fibre optic cable and then remove the cable. Optical free space laser communications systems are truly wireless (wire-free if you prefer) connections communicating through the atmosphere by light wave transmission, the beam being transmitted through open space rather than glass fibre.

The infra-red carrier used for transmitting the signal is generated either by a high-power l.e.d. or a laser diode. Two parallel beams are used, one for transmission and one for reception, taking a standard data, voice or video signal, converting it to a digital format and transmitting it through free space. Today's modern laser systems provide network connectivity at speeds of 155Mbit/s and will soon have the capacity to achieve 622Mbit/s and beyond with total reliability.

FULLY PROVEN

It is a fully proven technology too, with tens of thousands of installations worldwide. Lack of industry awareness is the chief problem but even this is changing, states Richard Redgrave, marketing director of British company PAV Data Systems Ltd. PAV is recognised as a leader in "last mile" networking, its products being exported worldwide. Its Windermere plant produces broadband optical wireless access systems with data rate capacities operating from T1 (1·5Mbit/s) through to SDI (270Mbit/s) at distances up to six kilometres.

The biggest drawbacks are severe weather conditions that interrupt the beam – extremely dense fog or sunlight shining directly into the receiver diode. Both of these cases are fairly rare and research shows that infra-red technology operates at an operational availability rate of between 99·1 and 99·9 per cent, equalling microwave radio's performance.

Birds are the other hazard for free-space light beam communications; what happens if a bird flies across the path? In fact birds can see the infra-red region of the spectrum and will usually avoid the beam. If a bird (or any other object) should pass through the beam, no harm will be done. The transmission will of course be interrupted momentarily, although Ethernet and Token Ring will re-transmit the data as per protocol.

BRIGHT RED FUTURE

Infra-red technology, claims the IrDA, is as secure as cable applications and can be more reliable than wired technology as it obviates wear and tear on the connector hardware. In the future, it is forecast that this technology will be implemented in copiers, fax machines, overhead projectors, bank ATMs, credit cards, game consoles and headsets. All of these have local applications and it is really here where this technology is best suited, owing to the inherent difficulties in its technological process for interconnecting over distances.

Outdoors too, its use is bound to grow as communications companies, broadcasters and end users discover how crowded the radio spectrum has become. Once infra-red's image issue has been overcome and its profile raised, the medium will truly have a bright, if invisible, future.

Haven't we heard this before . . .?

Cast your mind back, if you can, to the Summer of Love (perhaps there were several so let's call it 1968). Londoners devastated by the loss of Radio Caroline and gasping for an antidote to the all-too-restrained Radio 1 of the BBC were promised an entirely new station called Radio Love.

Radical in more ways than one, it planned to beat the state monopoly over the airwaves by broadcasting on optical frequencies beaming down on London from the top of Centre Point. Listeners would have their transistor sets converted with a photoelectric cell and could tune into their choice of music. That was the theory; the reality never came to pass. You probably think it's an April spoof, but it's true!

PROTEUS

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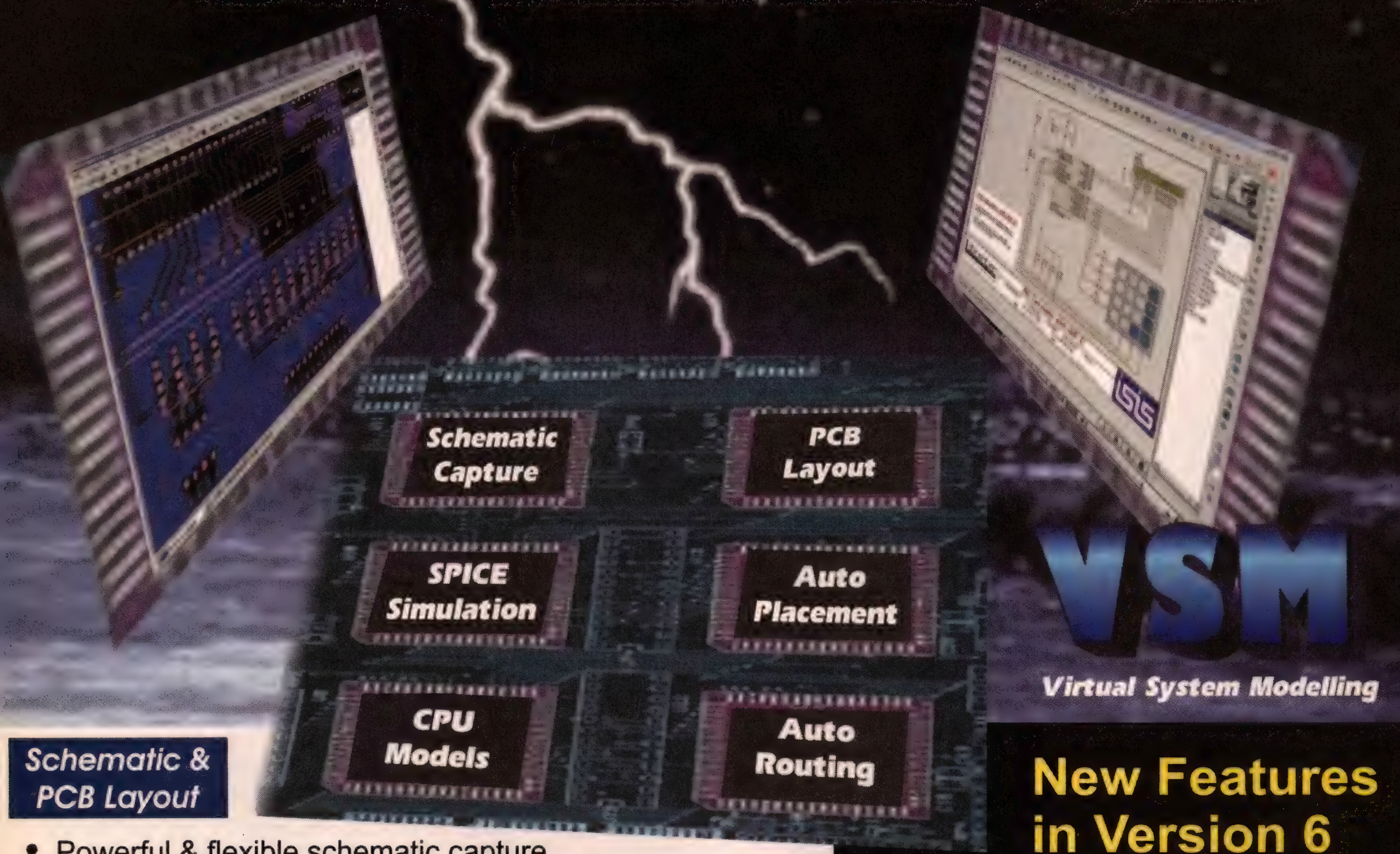

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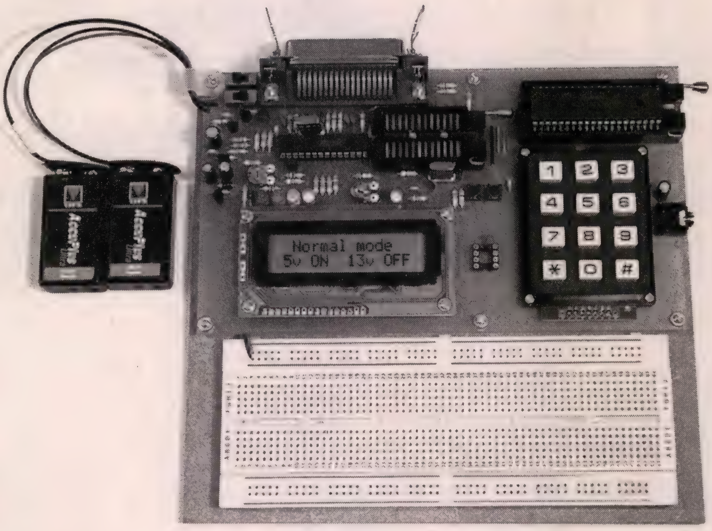
Learn About Microcontrollers



PIC Training & Development System

The best place to start learning about microcontrollers is the PIC16F84. This is easy to understand and very popular with construction projects. Then continue on using the more sophisticated PIC16F877 family.

The heart of our system is a real book which lies open on your desk while you use your computer to type in the programme and control the hardware. Start with four very simple programmes. Run the simulator to see how they work. Test them with real hardware. Follow on with a little theory.....

Our complete PIC training and development system consists of our universal mid range PIC programmer, a 306 page book covering the PIC16F84, a 262 page book introducing the PIC16F877 family, and a suite of programmes to run on a PC. The module is an advanced design using a 28 pin PIC16F872 to handle the timing, programming and voltage switching requirements. The module has two ZIF sockets and an 8 pin socket which between them allow most mid range 8, 18, 28 and 40 pin PICs to be programmed. The plugboard is wired with a 5 volt supply. The software is an integrated system comprising a text editor, assembler disassembler, simulator and programming software. The programming is performed at normal 5 volts and then verified with plus and minus 10% applied to ensure that the device is programmed with a good margin and not poised on the edge of failure. Requires two PP3 batteries which are not supplied.

Universal mid range PIC programmer module
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    + Book Experimenting with the PIC16F877 (2nd edition)
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Experimenting with PIC Microcontrollers

This book introduces the PIC16F84 and PIC16C711, and is the easy way to get started for anyone who is new to PIC programming. We begin with four simple experiments, the first of which is explained over ten and a half pages assuming no starting knowledge except the ability to operate a PC. Then having gained some practical experience we study the basic principles of PIC programming, learn about the 8 bit timer, how to drive the liquid crystal display, create a real time clock, experiment with the watchdog timer, sleep mode, beeps and music, including a rendition of Beethoven's *Für Elise*. Finally there are two projects to work through, using the PIC16F84 to create a sinewave generator and investigating the power taken by domestic appliances. In the space of 24 experiments, two projects and 56 exercises the book works through from absolute beginner to experienced engineer level.

Ordering Information

Telephone with Visa, Mastercard or Switch, or send cheque/PO for immediate despatch. All prices include VAT if applicable. Postage must be added to all orders. UK postage £2.50 per book, £1.00 per kit, maximum £7.50. Europe postage £3.50 per book, £1.50 per kit. Rest of World £6.50 per book, 2.50 per kit.
Web site:- **www.brunningsoftware.co.uk**

NEW 32 bit PC Assembler

Experimenting with PC Computers with its kit is the easiest way ever to learn assembly language programming. If you have enough intelligence to understand the English language and you can operate a PC computer then you have all the necessary background knowledge. Flashing LEDs, digital to analogue converters, simple oscilloscope, charging curves, temperature graphs and audio digitising.
Kit now supplied with our 32 bit assembler with 84 page supplement detailing the new features and including 7 experiments PC to PIC communication. Flashing LEDs, writing to LCD and two way data using 3 wires from PC's parallel port to PIC16F84.

Book Experimenting with PCs	£21.50
Kit 1a 'made up' with software	£52.00
Kit 1u 'unmade' with software	£45.00

C & C++ for the PC

Experimenting with C & C++ Programmes teaches us to programme by using C to drive the simple hardware circuits built using the materials supplied in the kit. The circuits build up to a storage oscilloscope using relatively simple C techniques to construct a programme that is by no means simple. When approached in this way C is only marginally more difficult than BASIC and infinitely more powerful. C programmers are always in demand. Ideal for absolute beginners and experienced programmers.

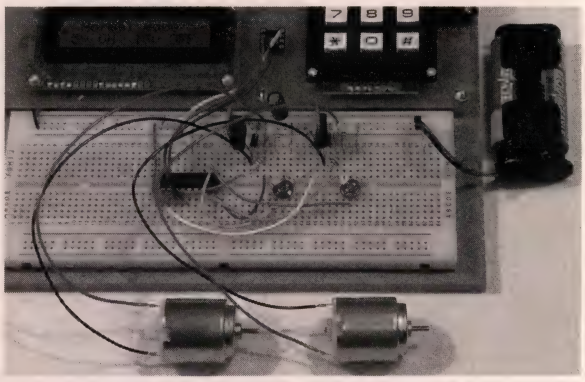
Book Experimenting with C & C++	£24.99
Kit CP2a 'made up' with software	£32.51
Kit CP2u 'unmade' with software	£26.51
Kit CP2t 'top up' with software	£12.99

The Kits

The assembler and C & C++ kits contain the prototyping board, lead assemblies,components and programming software to do all the experiments. The 'made up' kits are supplied ready to start. The 'top up' kit is for readers who have already purchased kit 1a or 1u. The kits do not include the book.

Hardware required

All systems in this advertisement assume you have a PC (386 or better) and a printer lead. The experiments require no soldering.



Experimenting with the PIC16F877

The second PIC book starts with the simplest of experiments to give us a basic understanding of the PIC16F877 family. Then we look at the 16 bit timer, efficient storage and display of text messages, simple frequency counter, use a keypad for numbers, letters and security codes, and examine the 10 bit A/D converter.

The 2nd edition has two new chapters. The PIC16F627 is introduced as a low cost PIC16F84. We use the PIC16F627 as a step up switching regulator, and to control the speed of a DC motor with maximum torque still available. Then we study how to use a PIC to switch mains power using an optoisolated triac driving a high current triac.

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News . . .

A roundup of the latest Everyday News from the world of electronics

LEGALISED DVD COPYING?

Could a new product allow you to copy commercial DVDs without breaking the copyright law? asks Barry Fox

A COURT in California must now decide whether PC owners can use an ingenious new software program that achieves what is apparently impossible. It makes perfect digital copies of DVD movie disks, without defeating their electronic copy-protection. The software, called DVDXcopy, has been developed by US company 321 Studios and is now on sale over the Internet for $100.

321 believes Xcopy steers clear of laws, including the 1998 Digital Millennium Copyright Act, which prohibit circumvention of copy protection, and Xcopy should be legal because it lets people make personal "back up" copies of DVDs they have bought.

Key Concept

The movie on a DVD is stored as digital code, compressed with the MPEG system. The code is encrypted with the Content Scrambling System, and unscrambling is only possible on an authorised DVD player or computer DVD ROM drive which contains CSS de-encryption keys secured in its control chips. The keys in the player mate with more keys buried in hidden parts of the DVD disk. If a computer is used to make a bit-for-bit copy of a DVD, the copy will not play on a DVD player because some of the vital keys do not copy along with the movie.

As extra security the analogue TV signal which comes out of the player is processed with the Macrovision analogue copy-protection system.

Unauthorised software called DeCSS can defeat the CSS digital protection, and black-box "signal cleaners" can be bought to defeat Macrovision. In most countries this is illegal. In the US the penalty can be five years in gaol and a $0.25m fine. But Xcopy does not defeat DVD's protection systems. Instead it shoehorns between them by copying the digital MPEG code just after it has been legitimately unscrambled from the DVD by an authorised player and just before the unscrambled code is converted into a protected analogue TV signal.

There's A Cache To It

Xcopy sends the unscrambled MPEG code to a temporary "cache" file on the PC's hard disk. Then it copies the cached code onto a blank DVD, and deletes the temporary store. The copy disk plays perfectly.

Hands-on tests support 321's claim that "It couldn't be easier! Install on Computer; insert Blank DVD Disk; press COPY NOW to Backup DVD". It is even possible to copy the copy DVD back to a computer hard disk, and from there to another blank DVD. It took only around an hour to copy a two hour movie. DVD Audio disks can also be copied; the Advanced Resolution tracks are ignored while Xcopy transfers the Dolby Digital and DTS replicas.

"Every backup copy you make is *exactly* like the original. Nothing is compressed or left off the disk," claims 321.

So now, says 321, people can take their favourite movies on the plane, in the car, or wherever they go. If the copy disk gets lost, stolen, or scratched, the original is still safe at home.

Muddy Waters?

Earlier this year 321 tested the legal waters with a system which spread a movie over several blank CDs. 321 then sued the nine major Hollywood studios, including Disney, Universal and Warner, when they complained. Now 321 is asking the District Court in San Francisco to rule that selling Xcopy software to make backup copies of DVDs onto blank DVDs does not violate the DCMA or any other US law. The studios have now counter-sued.

321 is also encouraging people to petition the US Congress for correction of "an unintended consequence of the DCMA".

The Motion Picture Association of America says it is staying silent until the case comes to court but the MPAA claims that $3bn is lost on piracy each year and is already finding "burner" factories which illegally copy movies to blank DVDs discs. The MPAA says it "looks forward" to the European Parliament passing tough laws like the DCMA.

CHATPEN

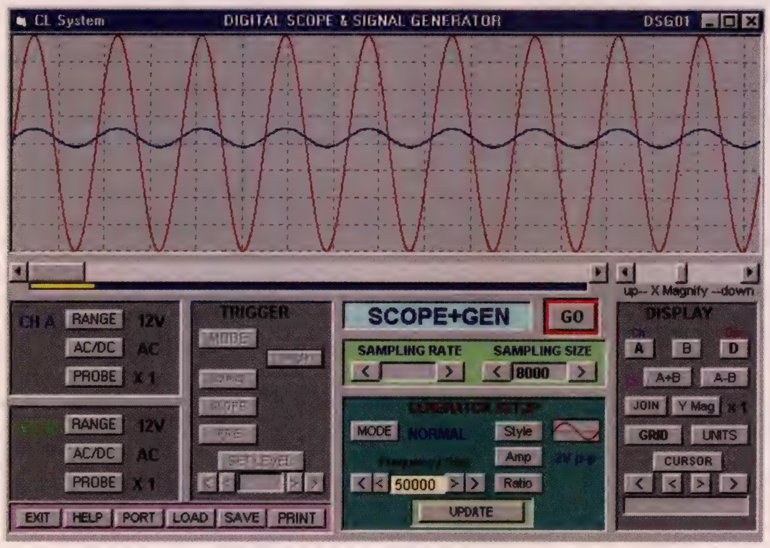
THE Feb '03 issue of the RSGB Members' magazine, *RadCom*, contains an article by Steve White G3ZVW in which he publicises a remarkable writing aid.

In brief, Steve highlights the so-called Digital Ink Pen produced by Anoto. It works like any other ball point pen, but it contains an interesting feature – the ability to store and wirelessly transmit what you have written.

The pen contains a tiny camera that scans your writing at 70 frames a second. It uses a grid to recognise when and where the tip is in contact with the paper and has a graphics capability of 86dpi. The captured data can be retrieved and transmitted, using Bluetooth, to a suitably equipped PC or cellphone, with a range of about 30ft.

Anoto's technology is used in the Sony Ericsson *ChatPen*, and Logitech produce a similar model. Anoto's web site is at **www.anoto.com**. Also do a search via **www.google.com**, on "Sony Ericsson Chatpen" – lots of entries to browse. The RSGB's web site is at **www.rsgb.org**.

PC DIGITAL SCOPE


CL System DIGITAL SCOPE & SIGNAL GENERATOR DSG01

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RANGE 12V
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PROBE X 1
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CL SYSTEM has announced a compact and smart module that turns your PC or laptop into a fully-fledged digital oscilloscope and signal generator. Ideal for capturing once-occurring events, the DSG samples at up to 30MHz, with a buffer size of 32K bytes.

It will generate sine, saw and triangular signals in normal and sweep formats, and is programmable to generate other waveforms. It supports data input from Microsoft Excel. With both scope and signal generator functions, the DSG becomes a versatile component tester, plugging into a PC printer port.

The system supports Win 95/98/ME/NT/2000/XT. Minimum spec is a 486 PC with 8MB of memory, EPP or ECP printer port, CD-ROM drive and 20MB disk space. Price starts at £139.

For more information contact CL System, Dept EPE, 35 Charterhouse Avenue, Wembley, Middx HA0 3DD. Tel: 07986 860815. Email: clang@clsystem.co.uk. Web: www.clsystem.co.uk.

SELF-DESTRUCT CDS

By Barry Fox

AFTER six years of legal manoeuvering, SpectraDisc of Providence, Rhode Island has won a master patent (US 6 343 063) that covers all its key ideas for making CDs, DVDs and computer ROM disks that self-destruct after a few minutes, days or weeks of use. The disk is doped with hygroscopic salts such as magnesium chloride and the surface covered with a peel-off barrier, like a record label.

When the barrier is removed to bare the disk for play, the salts start to pick up moisture from the air. The corrosive mix then begins to eat away the aluminium layer of the disk that reflects the laser light in the player. The disk can also contain an indigo dye which darkens as it absorbs light from the player's laser. So the disk plays for a while and then stops. Balancing the mix of salts and dyes controls the permissible play times.

KEENE'S CAT

KEENE Electronics was established in 1988 and has since evolved around the design, manufacture and distribution of audio and video accessories. Keene say that they sell interesting, useful, and sometimes hard to find bits and pieces designed to make your life easier, whether you are a camcorder specialist, home cinema fan or general gadget addict!

If you are any of these, Keene's latest catalogue, containing over a hundred A4 full-colour pages, is a *must* for you. There is too much to categorise, but it seems likely that you will find what you are looking for, as well as being helped to make more informed decisions about future purchases.

For more information contact Keene Electronics, Dept EPE, Unit 9, Old Hall Mills Business Park, Little Eaton, Derbys DE21 5DN. Tel: 0870 990 9000.
Fax: 01332 830551.
Email: sales@keene.co.uk.
Web: www.keene.co.uk.

MOTOR CROUZING

CROUZET manufacture a wide range of d.c. motors and associated gearboxes. They have recently appointed the Camis Group as their UK specialist distributor.

Martin Hyde, Crouzet's Marketing Manager, comments that customers will be able to have their d.c. motors and gearboxes configured locally in the UK. "The Camis offer includes supplying adapted products, control systems and even complete products and assemblies if required", he says.

For more information contact Camis Electronics Ltd., Dept EPE, Platts Road, Stourbridge DY8 4YR. Tel: 01384 441402. Web: www.camis.demon.co.uk.

MOTOROLA MICROS

READERS can perhaps be forgiven if they think that PICs are the only microcontrollers available. Whilst *EPE* has standardised on PICs, in fact there are numerous other microcontrollers manufactured by organisations other than Microchip.

Motorola, for example, have recently introduced a microcontroller that could well find favour with those who have been in electronics for some time and who remember with affection such microprocessors as the 6502 and the language structure used in it and others of similar type.

Motorola's new microcontroller family of 68HC908QT/QY devices could be of interest to such readers. One of the main technical features of the QT/QY family is the CPU08 core, which is code compatible with the industry standard HC05 micro. This was one of the leading controllers of the 90's, selling more than five billion units.

The 68HC908 devices, known also as the Nitron family of 8-bit flash MCUs, feature in-circuit reprogrammable memory of 1·5K to 4K bytes, and a number of on-chip peripherals, including a 2-channel 16-bit timer system with selectable capture, compare and PWM, and 4-channel 8-bit ADC.

An evaluation board is inexpensively available for these devices, featuring a battery powered 68HC908QT4, l.e.d.s, potentiometer, pushbutton switch, access to all I/O, software demo and application code. The board is available from Motorola's distributors worldwide at the suggested retail price of US$25.

Motorola offers 68HC08 web-based training, and has a large library of applications and complete reference designs. A large base of hardware and software development tools are available and the family is also supported by a free Metrowerks CodeWarrior Development Studio Special Edition.

For more information browse **www.motorola.com/mcu**.

TECHNOLOGY TRAINING

BOURNEMOUTH University has sent us a flyer promoting their School of Design, Engineering and Computing. This is said to maintain excellent links with industry and commerce through a thriving programme of research, consultancy, technology transfer and professional training. Bournemouth University continues to have one of the highest employment rates for new graduates, of all UK universities.

Short courses also form an important part of their Continuing Professional Development programme, usually having a duration of one to five days. They typically include hands-on laboratory sessions to enable you to practise new skills under expert guidance.

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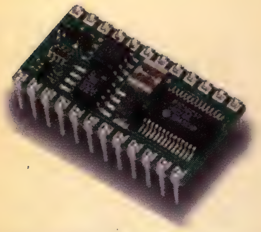
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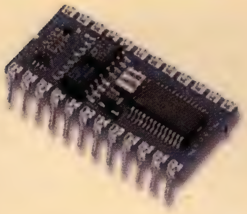
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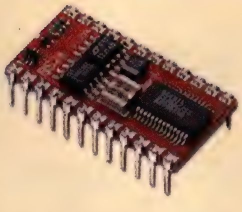
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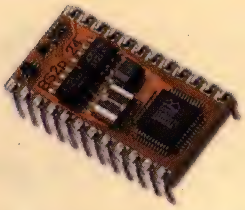
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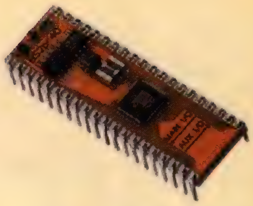
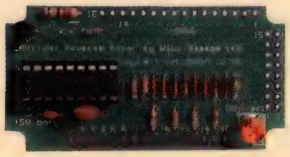
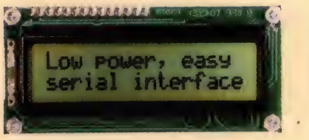
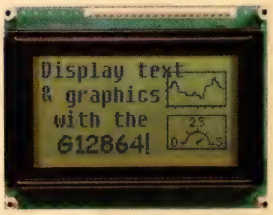

BS2P/40

Parallax BASIC Stamps - still the easy way to get your project up and running!







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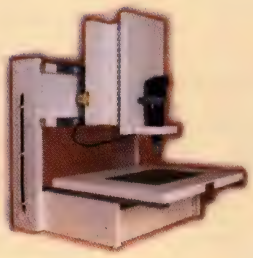
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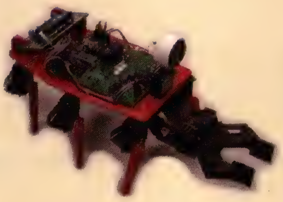
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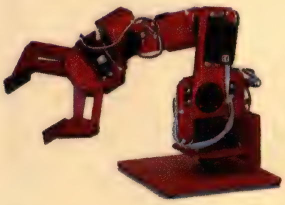
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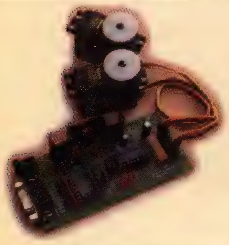
Bipeds

Robotic models for both the beginner and the advanced hobbyist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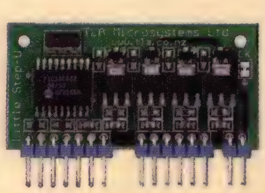
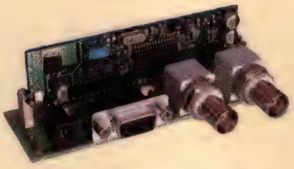
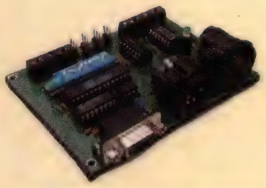
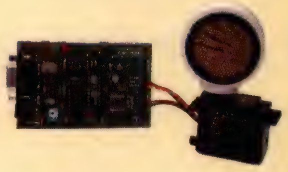
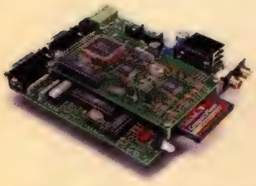

Motor Drivers


On-Screen Displays

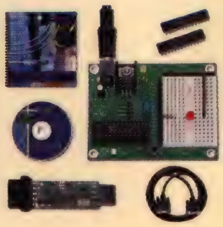

DMX Protocol


U/Sound Ranging

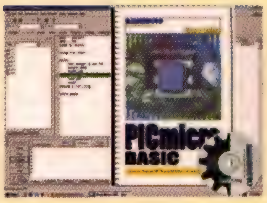
Animatronics and Specialist Interface-Control Modules


Quadravox
MP3 & Speech Systems

SensoryInc
Voice Recognition


Parallax
Ubicom Tool Kits

Tech-Tools
PIC & Rom Emulators



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INTELLIGENT GARDEN LIGHTS CONTROLLER

MAX HORSEY

An easy-build lights controller that knows when it's time to switch off

THIS project was developed for use with garden lights or any lighting system, including Christmas lights, which need to illuminate at dusk, but turn off around midnight.

Many existing lights are controlled by timers, but these have to be continually reset during Autumn and Spring as the period of daylight changes. Often lights are controlled by sensors such as l.d.r.s, in which case the light stays on all night, which is not ideal.

A system which turns on at dusk, but switches off at around midnight would require a light sensor, and a real time clock, which in turn requires a means of setting the time, and occasional re-setting. All very inconvenient!

HOW IT WORKS

Many garden lights are supplied with a power adaptor, and so the circuit was designed to operate on the 12V a.c. or d.c. supply that was already provided with the lighting set. For example, the garden lights in question were supplied with a power adaptor rated at 12V a.c. Hence the circuit first converts the supply to d.c. before regulating it down to 5V. The output to the garden lights is via a p.c.b. mounted relay, with mains rated contacts.

The block diagram of the system is shown in Fig 1. The light sensor monitors the level of light, and is connected to an analogue input at the PIC microcontroller.

The first time the system is used, the Set button is pressed during dusk, at the point at which the lights are required to come on. This setting is retained by the PIC even during power loss. It can be reset if required by pressing the Set button as described later.

The PIC indicates day or night, and whether the garden lights are switched on by means of three coloured l.e.d.s. Another output controls the relay which in turn switches the a.c. (or d.c.) supply to the garden lights. Any 12V power supply may be employed, and since the current required by the circuit is very small, it is ideally powered by the supply that is intended for the garden lights.

CIRCUIT DESCRIPTION

The full circuit diagram for the Intelligent Garden Lights Controller is shown in Fig.2. At the heart of the circuit is the microcontroller i.c., a PIC16F627.

Since the most convenient way of programming the device is by means of the PICAXE system (*see Nov '02*), resistors R1 and R2 are connected to the three-pin input connector TB1 to enable direct programming from the serial port of a computer. Note that this can only be done if a pre-configured i.c. (known as PICAXE-18) is obtained from Revolution Education – full details later.

MORE ON PICAXE

A PICAXE-18 i.c. is a PIC16F627 device into which special software has been added to enable serial programming

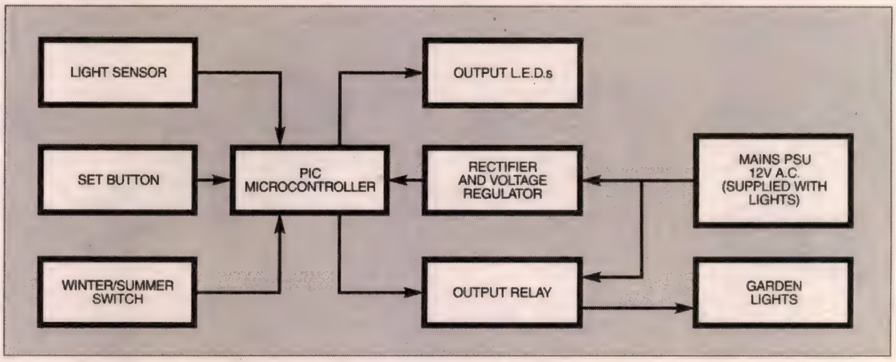
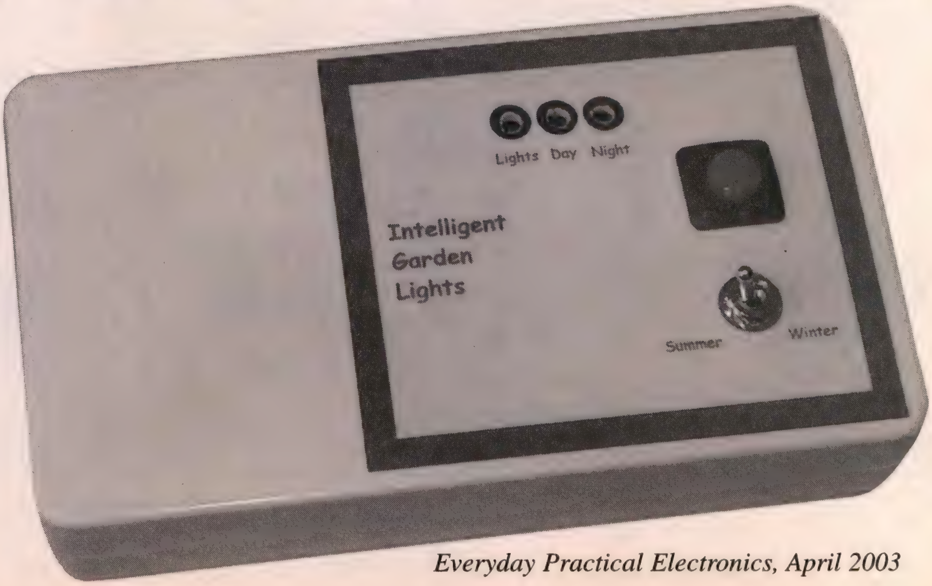


Fig.1. Block diagram for the Intelligent Garden Lights Controller.



via a lead direct from a PC. In other words, no programming hardware board is required, and the PIC is programmed "in-circuit". This, it is claimed, makes programming changes and experiments easy.

One of the disadvantages is that the PICAXE-18 is less widely available than a standard PIC16F627, and programs have to be fairly short. The advantage is that having bought the PICAXE-18 and serial lead all the required software is available free by downloading, or for a nominal charge on floppy disk. The programming system is in a form of BASIC, and is remarkably straightforward. Of course, you can download the program for this project from the *EPE* website.

FEATURES . . .

- Switches on automatically at dusk
- Times the length of the night until dawn, so that on subsequent nights the output is switched off halfway through the night (i.e. around midnight)
- Initial setting achieved by pressing a pushswitch at the chosen point during dusk. This value is retained in memory for subsequent nights
- Dusk turn-on setting and length-of-night settings are stored in EEPROM in case of power loss
- Summer/Winter selector switch can be fitted if required

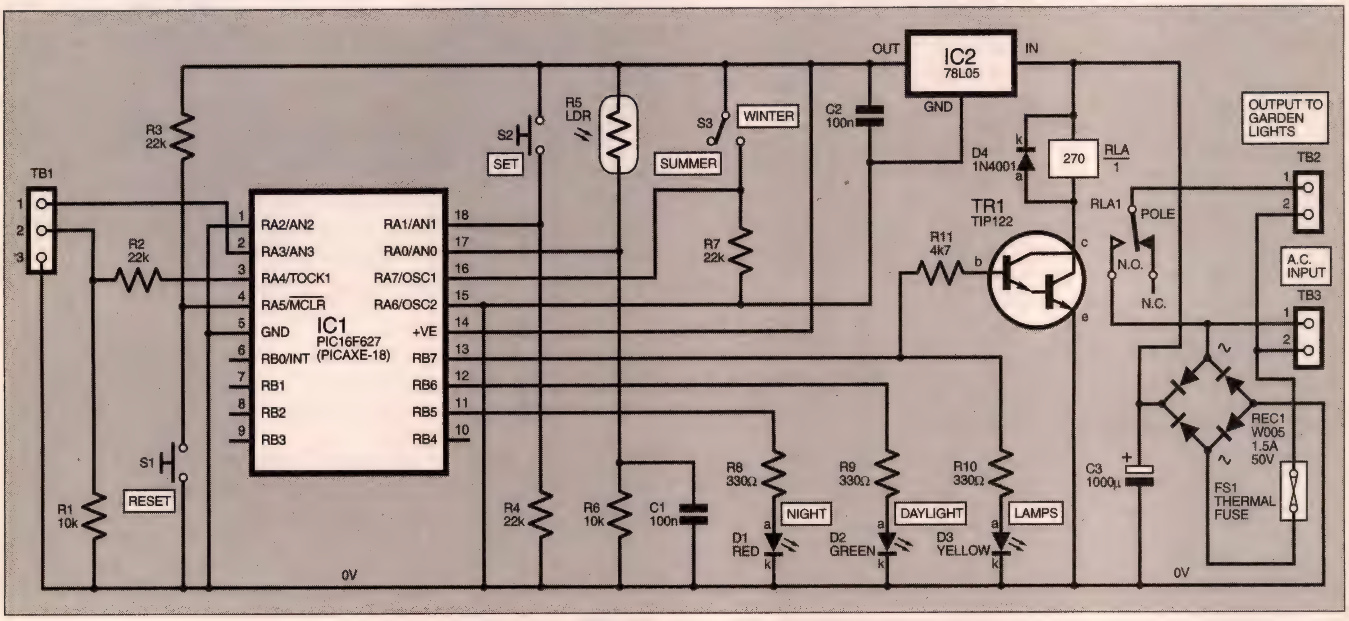


Fig.2. Complete circuit diagram for the Intelligent Garden Lights Controller.

For those wishing to program a PIC16F627 in the conventional way, a HEX version of the program is provided. Note that the PIC16F627 is similar to the popular PIC16F84A, and can be re-programmed many times.

However, it has an in-built oscillator, and is cheaper than the PIC16F84A. If serial programming is not required, connector TB1 can be omitted, but resistors R1 and R2 are best included to tie the serial input to 0V.

Pin 4 of IC1 is "master clear" ($\overline{\text{MCLR}}$). The Reset switch S1 may be omitted since the i.c. is reset every time it is powered up.

However, it may be required on the odd occasion with PICAXE-18 if latch-up occurs during programming. Hence two terminal pins may be employed rather than a switch so that they can be bridged with a screwdriver blade on the very rare occasion that reset is required. Note that resistor R3 is essential whether or not the reset function is required.

INPUT PINS

Pin 5 is the negative (0V) supply pin, and all unused Port A analogue inputs are tied to the 0V line. The Set switch S2 is connected to the input at RA1/AN1. Being a "normally-open" pushswitch, resistor R4 holds this pin at 0V. When S2 is pressed the pin switches to positive (5V). This is interpreted by the PIC as logic 1.

Pin RA0/AN0 is employed as the light level sensing analogue input. It monitors the voltage at the junction of R5, the light dependent resistor (l.d.r.), and resistor R6. This voltage will rise as the amount of light falling on the l.d.r. increases.

In this arrangement, the analogue pin can only detect voltages between 0V and about 3V, so the value of R6 has been chosen to provide an acceptable range during the period of dusk and dawn. A variable resistor (potentiometer) would often be chosen in place of R6, but this complicates the setting-up procedure, and a value of 10k should provide the range required.

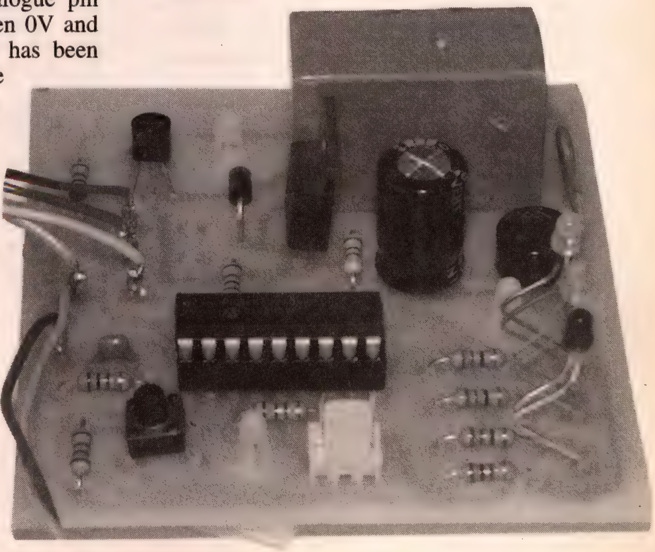
Note that the user still chooses the exact moment of "switch-on" by pressing the Set switch S2 at the required moment during dusk. The voltage at RA0/AN0 is noted by the PIC, and this value is remembered for subsequent automatic switch-on. Capacitor C1 removes any electrical noise that could be a problem if l.d.r. R5 is connected via long leads.

SUMMER/WINTER

Pin RA7 monitors the Summer/Winter switch S3. If this switch is omitted, then the default is "summer-time", i.e. the system will switch off at midnight during summer, and at 11pm in winter.

If S3 is fitted and closed, the circuit is set to "winter-time" (GMT) and will switch off at midnight during winter, but 1 a.m. in summer. The circuit can be permanently set to winter-time by fitting a wire link in place of S3. If S3 is included, then the circuit can be made to switch off at midnight all year round. Resistor R7 ensures that RA7 is never left "floating".

If the standard (i.e. non PICAXE-18) PIC16F627 is employed, then RA3/AN3



Finished circuit board. Note how the l.e.d. leads have been bent to align with the small holes in the case lid.

and RA4/TOCK1 should be connected to 0V since they are not required. Resistors R1 and R2 will maintain RA4 at 0V, the hex software configures RA3 as an input pin, so it may be tied to 0V by fitting a wire link to join pin 1 to pin 3 of connector TB1.

OUTPUT PINS

The PIC (IC1) can supply more than enough current to light an l.e.d. quite brightly. So, outputs RB5, RB6 and RB7 are used to supply the three l.e.d.s, D1 (red), D2 (green), D3 (yellow), which indicate night-time, daytime and "lights on" respectively. Each l.e.d. is supplied via current limiting resistors (R8, R9 and R10).

Pin RB7 also drives the Darlington transistor TR1 via base current limiting resistor R11. The transistor in turn switches on the relay, note that the 5V signal from the PIC is used to switch on the 12V d.c. supply for the relay coil. The transistor acts as an interface between the two voltages. The relay acts as an interface between the low-current 12V d.c. supply and the high-current 12V a.c. supply required for the lights. Diode D4 removes the back e.m.f. produced by the relay coil when it switches off.

Note that unused Port B pins should be left open-circuit i.e. not connected. The software configures all of port B (i.e. pins RB0 to RB1) as output pins.

POWER SUPPLY

The 12V a.c. supply (from the garden lights PSU) is applied via terminal block TB3. The supply is rectified into d.c. by means of bridge rectifier REC1. Note that if d.c. is applied to TB3 the circuit will work equally well, and the polarity of the d.c. is irrelevant. Capacitor C3 ensures that the ripple present on the rectified d.c. supply is smoothed.

Regulator IC2 provides a steady 5V supply for the PIC, and capacitor C2 removes any spikes present.

The power supply provided with the garden lights is capable of supplying a considerable current, and so the circuit is protected by means of a thermal fuse FS1. This fits into the circuit like a small capacitor and will protect the 12V d.c. section against short-circuits. The regulator IC2 limits the 5V supply to a maximum of about 100mA.

No protection is provided for the 12V a.c. supply to the lamps since this should be built into the power unit supplied. The suggested relay is capable of handling much more current than the maximum that can be supplied by a typical power unit, but if in doubt, an additional fuse can be fitted in series with the a.c. supply to the p.c.b. i.e. in series with pin 1 of terminal block TB3.

CONSTRUCTION

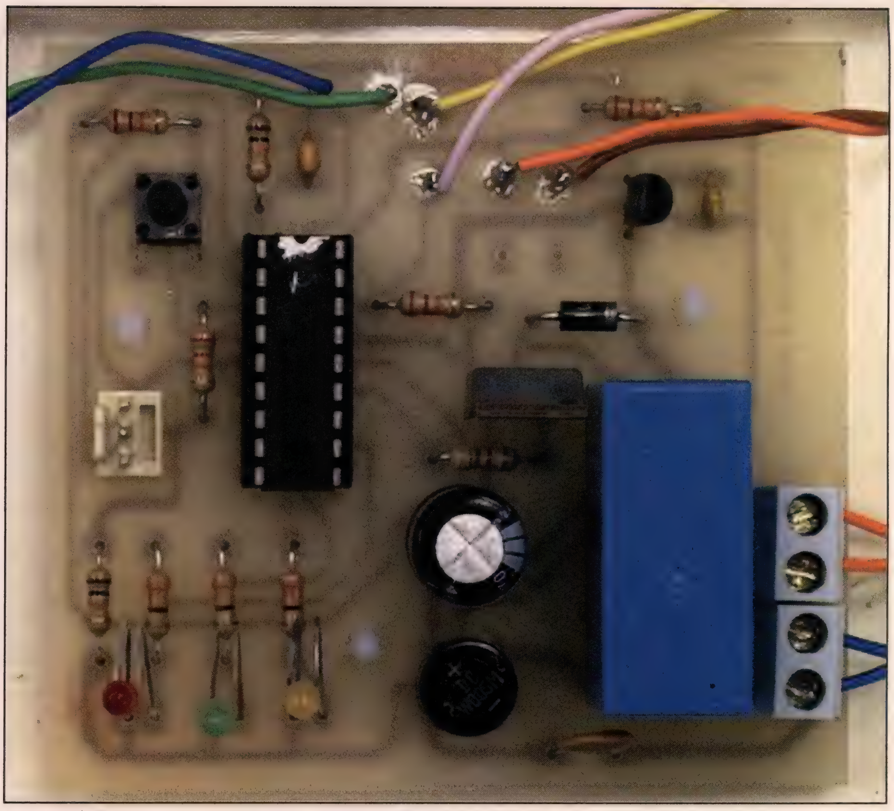
Construction of the Lights Controller is based on a small (73mm × 68mm) single-sided printed circuit board (p.c.b.). The topside component layout and full-size underside copper track master are shown in Fig.3. This board is available from the *EPE PCB Service*, code 389.

Begin construction by examining the p.c.b. to ensure that the holes for the relay and terminal blocks TB2 and TB3 are large enough. Also check that the three mounting holes, shown as square pads without any tracks will take the p.c.b. self-adhesive mounts.

However, do not yet fit any of these items, as it is easier to begin with the i.c. socket. Fit and solder this with its notch as shown in Fig 3. Next fit the smallest parts such as resistors and small capacitors C1 and C2.

Diode D4 must be fitted the correct way round, with its silver band as shown, as must the bridge rectifier REC1 whose positive lead is longer than the others. Capacitor C3 must be fitted with the positive (longer) lead also as shown.

Next fit the regulator i.c. IC2, with its flat side towards switch S2, and fit transistor TR1 with its metal tab nearer resistor R11. The 3-pin connector TB1 is optional,



Components mounted on the completed printed circuit board.

COMPONENTS

Approx. Cost
Guidance Only
£20
excl. case & serial lead

See SHOP TALK page

Resistors

R1, R6	10k (2 off)
R2, R3, R4, R7	22k (4 off)
R5	miniature light dependent resistor (l.d.r.)
R8, R9, R10	330Ω (3 off)
R11	4k7

All 0·5W 5% carbon film, except R5

Capacitors

C1, C2	100n disc ceramic (2 off)
C3	1000μ radial elect. 16V

Semiconductors

D1	3mm red l.e.d.
D2	3mm green l.e.d.
D3	3mm yellow l.e.d.
D4	1N4001 50V 1A rect. diode
TR1	TIP122 or TIP121 *npn* Darlington transistor
IC1	PIC16F627 or PICAXE-18 preprogrammed microcontroller (see text)
IC2	78L05 5V 100mA voltage regulator
REC1	W005 1·5A 50V bridge rectifier

Miscellaneous

RLA	12V 270Ω coil, p.c.b. mounting relay, contacts rated 10A 240V a.c. or more
S1	p.c.b. mounting switch, push-to-make (optional – see text)
S2	pushbutton, low profile switch (push-to-make)
S3	s.p.s.t toggle switch
TB1	3-pin serial connector (shrouded 3-pin header)
TB2, TB3	2-way screw terminal block, p.c.b. mounting (2 off)
FS1	0·5A thermal fuse (see text)

Printed circuit board available from the *EPE PCB Service*, code 389; plastic case, size 142mm x 81mm x 30mm approx.; 18-pin d.i.l. socket; serial download lead for PICAXE-18 (see text); connecting wire; solder pins; solder etc.

and required if the PIC is a PICAXE-18 type, and programmed directly from your computer. If TB1 is required, ensure it is fitted with its locating "tongue" towards the outer edge of the p.c.b.

The l.e.d.s D1, D2 and D3 may be mounted directly on the p.c.b. Ensure that they are fitted the correct way round, and allow them to stand well proud of the board. It will then be possible to fix the p.c.b. into the case with the l.e.d.s showing through three holes drilled in the top.

If the l.e.d. wires are bent a little, they may be positioned more easily, and fine-tuned to be at the correct height. Any colour scheme can be used, but in the prototype D1 was Red, D2 Green and D3 Yellow.

ALL SWITCHED ON

Switches S1 and S2 can be p.c.b. mounting types if desired, although as explained earlier, S1 is hardly ever needed, and a pair of terminal pins will suffice in the unlikely event that the circuit requires a reset. The terminal pins must be fitted on the pads nearest to resistor R3, the other pads are simply to locate S1.

The prototype employed a low-cost p.c.b. switch for S1, as shown in Fig.4 and the photographs. S2 is the Set switch, and is likely to be required on the casing. Hence a pair of wires should be fitted to the pads nearest the outside edge of the p.c.b.

Switch S3 is optional and is designed to select between Summer-time and Winter-time. If S3 is omitted the system defaults to summer-time. This will cause the system to switch off the lights at 1 a.m. during the summer and at midnight during the winter.

Alternatively, a wire link in place of S3 will cause the system to switch off the lights at midnight during the summer, and 11 p.m. in winter. If S3 is included you will be able to set the system to switch off the lights at midnight all year round.

Wires should also be fitted for the l.d.r. (R5). The thermal fuse FS1 can be fitted either way round, followed by the relay. Some care must be taken to make all the relay pins find their correct holes. There are two types of p.c.b. mounting relay in common use, and the p.c.b. has been designed to accommodate either type. Hence the extra four holes which are not required.

Now fit the p.c.b. mounting terminal blocks TB2 and TB3, ensuring that the

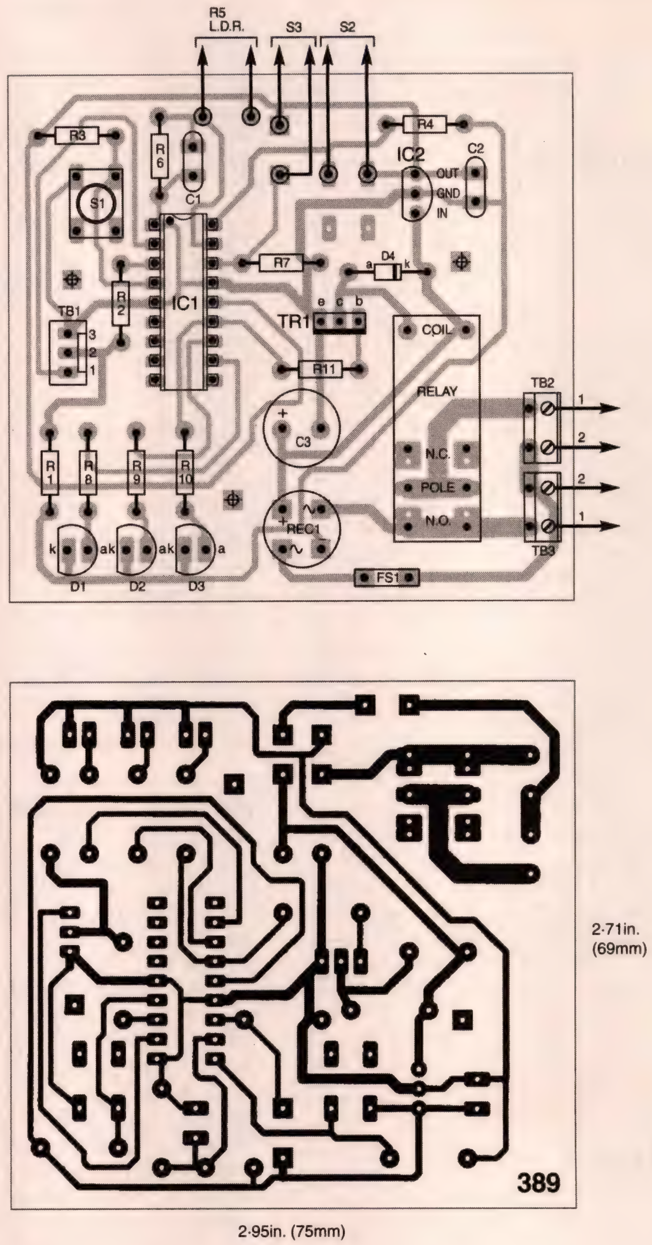
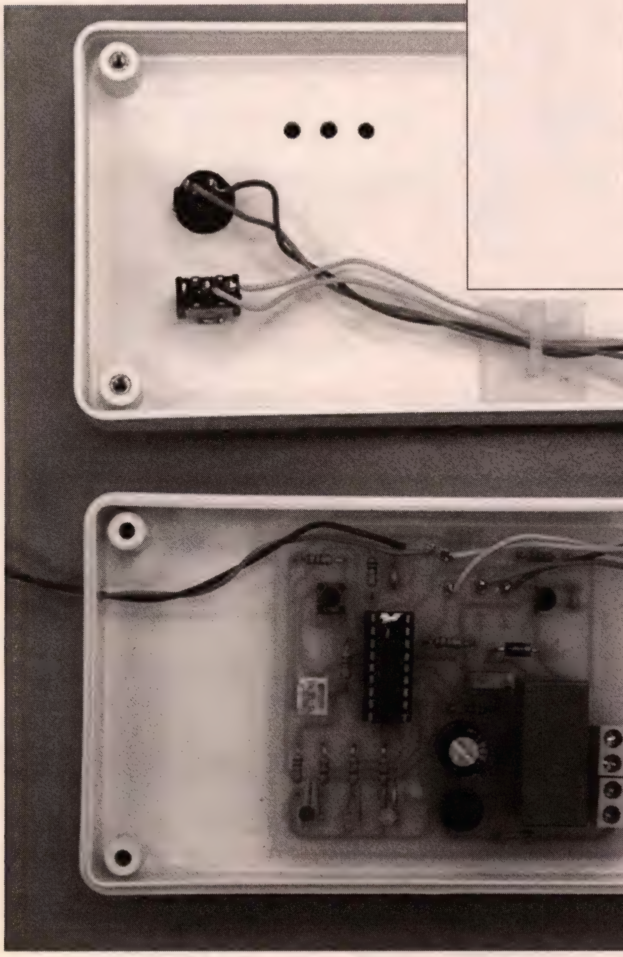


Fig.3. Lights Controller printed circuit board component layout and full-size copper track master.



Completed unit showing the p.c.b. mounted in the case base and the three l.e.d. locating holes in the lid.

holes for the wires are facing the outside edge of the p.c.b. Finally insert the programmed PIC into its socket, taking static precautions and ensuring it is seated the correct way round, with its notch (or dot) towards resistor R6.

CASING UP

The p.c.b. may be housed in a slim white case measuring 140mm × 80mm × 30 mm, as shown in Fig 4. Drill holes for the three l.e.d.s, noting that if the holes are suitably aligned, the l.e.d.s may remain housed on the p.c.b. as shown in the photographs. Also drill a hole for pushswitch S2, and optional Summer/Winter switch S3. Note that S1 is not required once the PIC has been programmed and so no provision need be made.

Drill a hole for the power supply cable, and the cable connecting the garden lights, and a hole for the wire linking the l.d.r. with the circuit. You should include a small cable strain relief grommet in the power and lights cable entry holes.

The power supply from the lights power supply transformer is connected directly to terminal block TB3, and the garden lights are connected directly to terminal block TB2. In view of the large current involved it is advisable to use these direct connections.

The power unit supplied with the garden lights should already have fuse protection (probably a thermal fuse) built in. If this is not the case then an additional fuse should be included in the supply linking the power input to pin 1 of terminal TB3. This will guard against a short circuit occurring in the cable feeding the garden lights.

The circuit board. may be fixed into the case using p.c.b. self-adhesive supports, taking care to align the l.e.d.s with the holes in the case.

TESTING

Commence the testing procedure by connecting the l.d.r., but avoid connecting the garden lights or garden power unit at this stage. Testing the circuit with a 12V d.c. supply limited to 1A or less, will ensure less damage if mistakes have been made. A 9V PP3 battery should work in this application and is even less likely to cause damage.

When power is applied, one of the l.e.d.s – probably D2 – the green Daylight indicator should light. This at least indicates that all is likely to be well.

Partly shade the l.d.r. and press switch S2. Continue shading the l.d.r. The yellow (Lights-On) indicator D3 should light, followed by red D1 (Night). Unshading the l.d.r. should force the system back to green (Day). Each time D3 switches on or off the relay should click.

Further testing is difficult because of the long time delays involved. A 47k potentiometer, wired as a variable resistor, fitted in place of the l.d.r. will enable controlled testing as described under the Fault Finding section.

If all is well, double-check that capacitor C3 is the correct way round, since this is the only component that could explode if wrongly fitted! Connect the garden lights to terminal block TB2, and connect the high-current 12V a.c. (or d.c.) supply to TB3.

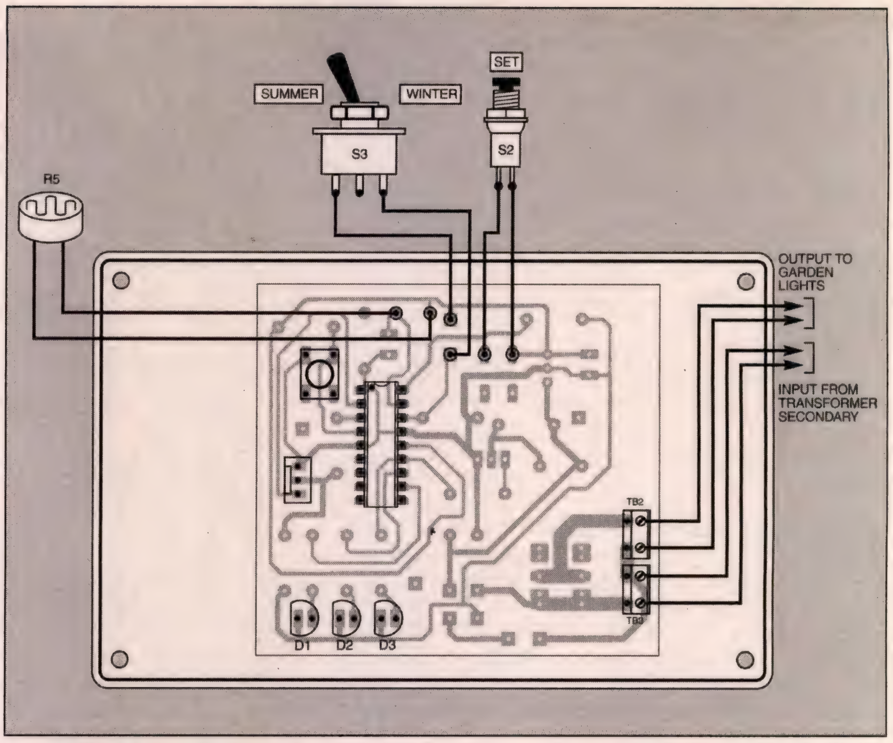


Fig.4. Interwiring details from the circuit board to off-board components.

FAULT FINDING

Testing any timing circuit can be a little tedious, especially one designed to operate in a 48 hour cycle. Remember that the system measures the length of the first night in order to switch off half way through the second night.

Begin any "fault finding" by making simple voltmeter readings, starting with the voltage reading across pin 5 (GND) and pin 14 (+VE) of IC1. This should be close to 5V. A higher reading probably indicates that the regulator IC2 is at fault, or the wrong way round.

Connect the negative of the voltmeter to the d.c. 0V line in the circuit – noting that neither of the inputs to TB3 are at 0V. A suitable 0V (GND) point is the cathode (k) side of any l.e.d. Now take readings at the other pins on IC1, according to the circuit description at the beginning of this article.

If you need to test the circuit in a controlled way, begin by temporarily replacing the l.d.r. with a 47k variable resistor (potentiometer). This will allow you to control day and night more easily. A low resistance setting will simulate daytime. Set the variable resistor to half way, and press pushswitch S2. Now increase the resistance to simulate night-time.

TIME LAPSE

The main timing loop takes just under six minutes per cycle. So when testing, you need to simulate a night lasting for at least 12 minutes in order to provide a rough guide as to whether the circuit is working. Be aware, however, that the time subtracted during summer-time is one hour, and so either set the circuit to winter-time by closing switch S3, or allow at least two hours of simulated night.

If you are programming using PICAXE, you can speed up the program by about 100 times by reducing the 'pause 1384' to 'pause 13'. This will allow testing for times of as little as 10 seconds, though two minutes or more is recommended to avoid problems caused by the "summer time subtraction".

Note that the Summer/Winter switch S3 is best set to winter, since a value of 'pause 13' will cause 32 seconds to be subtracted from the night-time calculation, and this may cause confusion. Setting S3 to winter, i.e. closing S3, will prevent the 32 seconds subtraction. Of course, if S3 has been omitted, then the subtraction will always occur and you will need to remember that the switch-off time will be 32 seconds shorter than expected.

FINAL SETTING-UP

The system is best set up during daylight, so that pushswitch S2 can be pressed at dusk. If you have already tested the p.c.b. as described earlier, then you can re-set the point at which the lights switch on either by pressing S2 at an earlier time, or by pressing and holding S2 if you wish to set a later time. This is described in detail in the Operating Instructions panel.

The l.d.r. should be fixed against the inside of a window, and should be shaded against direct sunlight since this will eventually damage the device. Avoid a position in which the l.d.r. may be fully shaded by somebody walking past, or a position in which direct light from the headlights of cars might pose a problem.

The prototype devices proved fairly immune in this respect, and street lights etc., were not a problem. Remember that the system will only provide an accurate calculation for switching off the lights, on the **second** and subsequent nights.

HOW THE PROGRAM WORKS

The PICAXE (BASIC) program (called 'glight10') will be described. The HEX version, also available for download was derived from the same original, with minor alterations ('glight11'). So, for PICAXE

OPERATING INSTRUCTIONS

1. During daylight, connect power to the system. The green (Day) l.e.d. should light.

2. Wait until dusk, and press Set button S2 at the desired moment to switch on the lights. (Note that the anti-bounce feature of the system may require you to hold the button for a brief period, before the circuit responds). The yellow (D3) and red (D1) l.e.d.s should light. Red indicates Night, and yellow indicates the garden Lights should be on. The system will now measure the length of the night.

3. During the first night, the garden lights will stay on for around 4 to 5 hours, but the following night the garden lights will switch on as set the first night, and will stay on until around midnight (i.e. half the length of the night).

4. Switch the lamps off at any time by pressing S2 until the yellow l.e.d. (D3) switches off. Release S2 immediately. Note that the system will continue to measure the length of the night. If you do not release S2 immediately, the green l.e.d. will light indicating that you have reverted to daytime. The previous night's length will be retained.

5. The Summer-Time switch setting (S3) will cause the lights to switch off one hour earlier, i.e. at midnight during summer time. This is the default setting i.e. if S3 is not fitted.

6. Note that both the "lights-on" and "length of night" settings are saved in EEPROM. Hence if power is lost, or if you press reset, the settings will be retained.

7. CHANGING THE SETTINGS

- To set the lights to switch on earlier: Simply press S2 at the desired moment.
- To set the lights to switch on later: At the required moment, press and hold S2 until the system toggles to daylight (green l.e.d.) then back to 'lights on'.

use 'glight10', but if you wish to use a conventional programmer, then use the hex file provided.

We cannot provide an assembly code listing of the hex version since this would break copyright rules, as each line of BASIC is converted to an assembly sequence designed by Revolution Education. If you wish to convert from BASIC to assembler it is necessary to buy a (modestly priced) Revolution Education programmer. Note however that certain lines in the BASIC listing are not supported by the conversion process, e.g. 'divide by 2' and 'readadc'.

PICAXE-18 BASIC LISTING

The program begins with the command 'start:' followed by some settings read from EEPROM. Hence if the circuit is switched off, the settings will be retained. The value of b3 (light level) will be zero initially, but an initial value of zero for b4 (length of night) will cause an error, hence b4 is made 50 when the circuit is first switched on.

When the 'dark:' loop is entered, the green l.e.d. is switched on (high 6). The program reads the light level at input RA0 (readadc 0,b0) and places the result in variable b0. If this value is less than the stored value (b3) then the lights are switched on, otherwise the program loops back to 'dark:'.

If input RA1 is made high by pressing S2, the program jumps to 'hold:'. This copies the value of b0 into the variable b3. It also writes the value into EEPROM memory allocation 0 (write 0,b3). Hence the value set will always be remembered, even during power loss.

The label 'switon' switches on the lights (high 7). The system then enters two loops, 'loop1:' and 'loop2'. The combination of the two loops allows the system to time for up to 24 hours, yet still check at roughly one-second intervals, whether S2 has been pressed. (Interrupts as used in assembly code are not available with PICAXE devices; hence the switch must be checked repeatedly within the loop). The system now times the length of the night from the point at which the circuit registered dusk, to the same light level at dawn.

'Loop2:' simply counts from 0 to 250, pausing 1·384 seconds per loop. It also turns on the red l.e.d. (high 5), reads the light level to check for dawn, and checks whether S2 has been pressed. After 250 loops it returns to 'resetb2:' and variable b1 is incremented. If b1 exceeds the value of b4 then the system jumps to 'switoff:', and the lights are turned off.

Once the light level at dawn is equal to the dusk level set the previous evening (b3) then the program will jump to 'setb4:'. Now the lights are switched off (if they haven't already been), and variable b4 is set to half variable b1. Hence the length of the night (b1) is halved so that the lights will switch off at midnight in future.

A manual over-ride is provided, whereby, if S2 is pressed, (pin1 = 1) before the automatic switch off time, the system will jump to 'switoff', so that the garden lights are turned off, then allowing the system to return to 'loop2:' and continuing the timing operation. If S2 is held down, the system will jump to 'delay:' which reverts back to the daylight loop without measuring the length of the night.

SUMMER/WINTER

An error occurs during summer time, where the point at which the lights would turn off is 1 a.m. since this is half way through the night. Hence the line 'let b4 = b4-10' reduces the value of b4 by 1 hour to correct the error. However, in winter time the error does not occur and so if switch S3 is closed (pin7 = 1) the system jumps over the 'let b4 = b4-10' command.

The value of b4 is written into EEPROM memory allocation 1 (write 1,b4). Hence if power is lost, or reset is pressed, the system will still remember the length of the night.

POWER CUTS

The program has been designed for "power-up" during daytime, and if a power cut occurs during the day, the light and night-length settings stored in EEPROM will ensure normal operation when power is restored. However, if power is restored at night, the system will calculate the night-length from the moment of power-up, so causing an error.

Hence, variable b6 is used to inform the program whether power is restored during daylight or night. If power-up occurs during the day, the 'dark:' loop will cause b6 to be set to 1. If power up occurs at night, b6 will remain at 0, and at the label 'setb4:' the system will skip back to 'dark' without setting b4. Therefore, the previous night's calculation will be used for the following night.

RESOURCES

The hex file can be used by readers to program PIC16F627 devices, using their own PIC programming hardware. It should be noted, however, that readers who wish to modify the BASIC program to suit their own requirements need to use the PICAXE programming software and serial lead that is available from Revolution Electronics, Dept *EPE*, 4 Old Dairy Business Centre, Melcombe Road, Bath BA2 3LR. Tel: 01225 340563. Email: info@rev-ed.co.uk. Web: www.rev-ed.co.uk. (This software is *not* available from *EPE*). They also supply blank PICAXE-18 microcontroller i.c.s.

The BASIC and hex files are available for free download from the *EPE* ftp site. This is most easily accessed via the main page of the *EPE* web site at **www.epemag.wimborne.co.uk**. At the top is a click-link saying **FTP site (downloads)**, click it then click on **PUB** and then on **PICS**, in which screen you will find the Garden Lights folder.

The software can also be obtained on 3·5-inch disk (Disk 6) from the Editorial office. There is a nominal handling charge to cover admin costs. Details are given on the *EPE PCB Service* page, and in this month's *Shoptalk*, which also gives details about obtaining pre-programmed PICs.

☐

New Technology Update

Improved fabrication processing promises increased memory cell capacity. Ian Poole reports.

MEMORY is one of the major elements in today's electronics scene. Equipment from mobile phones to games consoles, and PC cards to organisers all use increasing amounts of memory.

One area in which several strides forward have been made in recent years is for system-on-chip (SoC) designs. Already the level of memory usage in these highly integrated devices has grown considerably and this means that the spotlight is firmly fixed on this area of the technology.

More For Less

Most of the designs for these systems use memory cells that employ the traditional six transistor SRAM cell. So great was the demand for memory that an SoC design typically utilised over 20% of its area purely for memory.

In response, a company named MoSys developed a new memory cell in 1998 that used only one transistor. Named 1T-SRAM, it has many similarities to a dynamic RAM (DRAM) having only a single transistor in its topology.

As it has fewer transistors in the basic cell, 1T-SRAM technology gave a two-fold improvement in density. This was a particularly valuable improvement as it enabled much better utilisation of the chip area. It also gave, it is claimed, cost reductions of between 50% and 70% as it used some metal layers rather than all polysilicon ones.

With the large costs involved in introducing new processes into semiconductor manufacturing plants, the fact that traditional CMOS processes can be used is of considerable importance.

A further advantage of the 1T-SRAM technology is that it requires less power than the traditional six transistor SRAM cells. It uses around 75% less power, a factor that is very beneficial. Not only does it mean that there is less drain on the power supplies, an important factor in many of today's designs, but it also assists in the design of the chips as less heat has to be removed.

The memories maintain compatibility with other memories and architectures through the use of the familiar SRAM interface. The MoSys system of partitioning the memory into large numbers of small banks allows the refresh cycle to take place transparently in the background. By providing a cache, even the banks that are frequently accessed can function in this mode. This enables a very fast random cycle performance with low power consumption, and full compatibility with standard logic processes.

Further Developments

The next stage in the development of the technology was to provide an even lower level of power consumption. This was achieved at the beginning of 2001 with the introduction of their 1T-SRAM-M. This development introduced a leakage suppression circuit that enabled a standby current of only 10 microamps per Megabit of memory to be achieved.

With the rapid increase in demand for this type of memory, further developments were made in 2002 when a new improvement to the technology was launched. Called 1T-SRAM-R it included further features including a new technique called Transparent Error Correction. This is a patented MoSys development that enabled repair during manufacture, or a slower self repair at power up.

Latest Generation

The latest stage in the evolution of this memory technology has been achieved with the introduction of the new MoSys 1T-SRAM-Q memory. This development provides four times the density of normal six transistor SRAM and is still able to provide excellent scaleability to future nanometre scales.

The new technology achieves its performance by "folding" the capacitor in the basic memory cell as shown in Fig.1. Using this technique it is possible to reduce the size of the basic memory cell whilst still providing the same charge storage as in the previous 1T-SRAM capacitor.

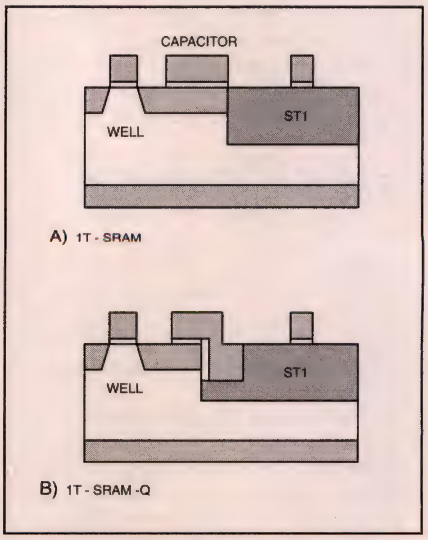


Fig. 1. Comparison of the new cell with the folded capacitor and previous generations

The new technology offers further improvements by providing an improved ratio of stored charge to parasitics. This enables a much better signal-to-noise ratio to be achieved that ultimately results in fewer data errors.

The smaller capacitor also results in an improved ratio of stored charge to cell circuitry giving a reduced level of power consumption. The shorter wires, fewer parasitics and lower voltage all result in lower levels of power dissipation. As a result the overall power consumption of the cell can be reduced without impacting on its speed or reliability.

Fabrication

The new folded capacitor results from the use of a new capacitor topology. Rather than just stretching it horizontally, the capacitor is extended in the vertical plane.

An additional mask is used in the fabrication process, along with two additional steps to etch a well in the shallow trench isolation layer. This well is then filled with polysilicon. Oxide forms naturally, bending the horizontal capacitor plate down into the well.

The capacitor retains a large effective area, even when the cell structure is scaled down. It has also been shown to be very robust, a critical feature in memory applications. This issue could have been of concern because bends in the plate could increase the electric field to a point where breakdown might occur.

Optimistic

The process has been optimised so that the additional etch and implant steps occur before the transistors are fabricated. This is an important feature because it means that the active devices do not undergo any additional thermal cycles.

Thermal cycles affect the performance parameters of the transistors and accordingly the development engineers have been very confident that the new process has not had any impact on the performance of the basic cell.

Although two additional steps are required in the fabrication process this only adds about 5% to the manufacturing cost. Against this, the size reduction means that the overall costs fall, typically by about 25%. This is a real achievement in today's semiconductor industry where much smaller cost improvements are seen as major breakthroughs.

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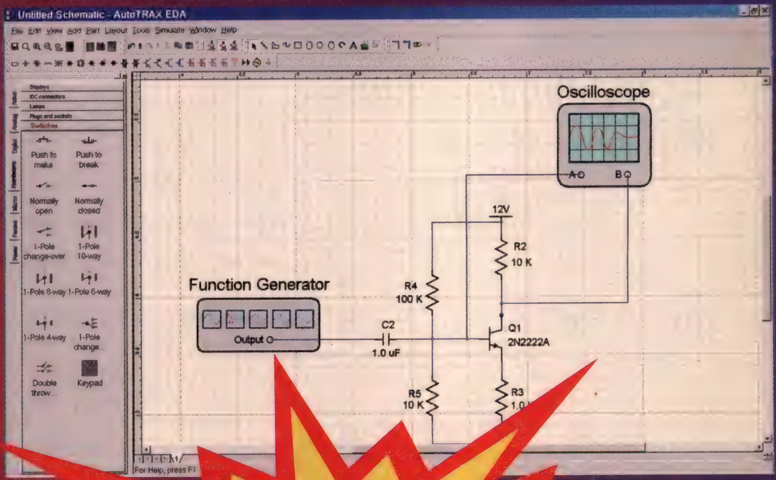

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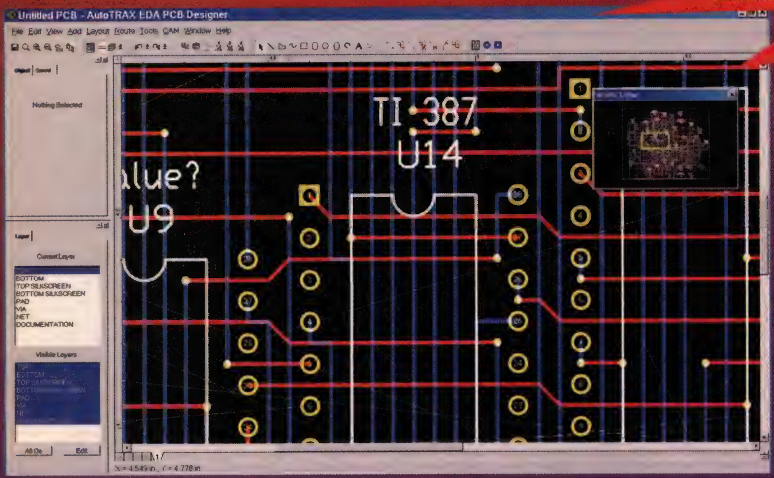

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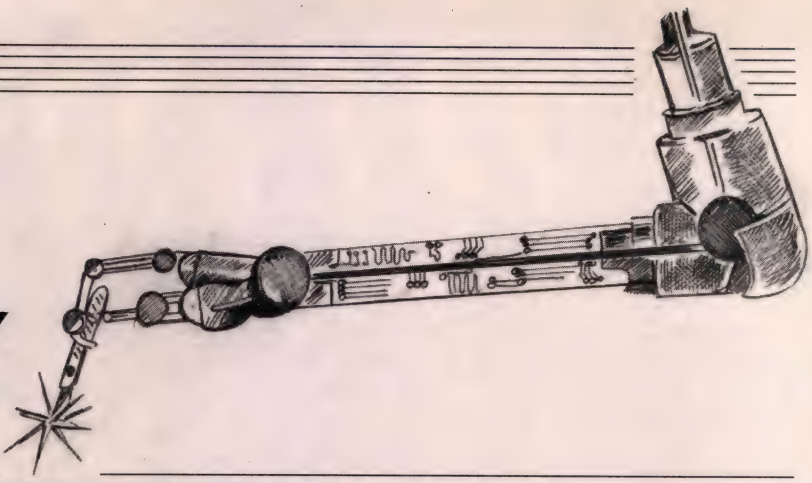


ALAN WINSTANLEY and IAN BELL

This month we explain how to read circuit diagrams and suggest a CMOS op.amp solution for a reader's application.

Circuit Guide

Can anyone recommend a really good book that deals with how to follow and understand circuit diagrams? This is needed for some GNVQ coursework. Thanks from ***John***. Posted in the *EPE Chat Zone* message board (**www.epemag.wimborne.co.uk**)

Circuit diagrams often bemuse newcomers to electronics. Experienced constructors can read them like a book and after tracing a few lines around with finger and thumb, they quickly get to understand the "plot".

To beginners and novices though, a circuit diagram can be all but incomprehensible, so in this month's *Circuit Surgery* we start a short mini-series on how to interpret electronic circuit diagrams, highlighting some of the pitfalls that trap beginners along the way.

Tour Guide

A circuit diagram is actually nothing more than a road map. If towns and cities are electronic components, then the lines on a map that represent the roads are simply electrical *conductors* – the wiring and interconnections that join everything together properly.

In electronic terms, we can join components together in two ways. We can use a printed circuit board (p.c.b.) to carry most of the components, and the copper tracks on the board are then specially designed to connect the components together into a circuit.

Take a look through any of the project pages of *EPE* and you will see a wide variety of p.c.b. patterns, each created specially by the project's designer, probably using computer software. A p.c.b. does most of the hard work for you, and takes away much of the guesswork of assembly.

The second way of connecting parts together is obviously to use ordinary copper wire. This is necessary to connect printed circuit boards to any larger off-board components (e.g. controls or plugs and sockets) in a process often called "*interwiring*". Obviously, entire circuits could be built by using wire conductors, but a printed circuit board is far more compact and reliable, and offers a much higher chance of the circuit working first time.

Road Sense

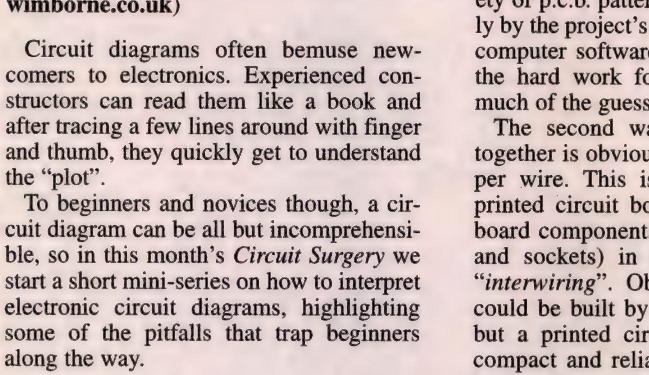
In circuit diagrams, conductors are represented by solid lines – just like the roads on a road map. The lines in a circuit diagram are therefore the copper tracks on a p.c.b. or the wires that interconnect parts to each other. One problem with circuit diagrams, however, is that we cannot tell whether the solid line is the equivalent of a motorway or just a narrow country lane: they are only shown as *conductors* (roads)!

We have to read the diagram to see whether a conductor is carrying a small audio signal, or whether it's driving a heavy mains voltage load, or carrying vast amounts of high-speed data. The difference is critical when it comes to assembling a project, because we have to ensure that the correct type of cable or wire is used, that it is routed properly and that adequate insulation is used where necessary.

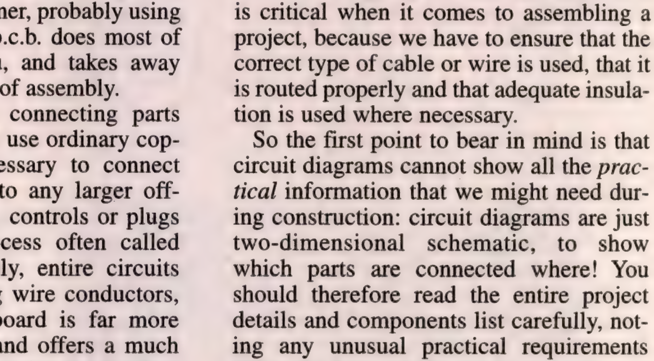
So the first point to bear in mind is that circuit diagrams cannot show all the *practical* information that we might need during construction: circuit diagrams are just two-dimensional schematic, to show which parts are connected where! You should therefore read the entire project details and components list carefully, noting any unusual practical requirements along the way. (In *Shoptalk,* we give you any important buying tips or late-breaking news, and it should always be checked carefully.)

Missed a Blobby

The amusing but anarchic character "Mr. Blobby" is known on UK TV for causing chaos and damage, and that is exactly what happens in an electronic circuit when we get our wires crossed (literally).



Left, panel (chassis) mounting rotary potentiometer, top right: enclosed preset, open (skeleton) preset, multiturn, side adjust, preset "resistors".



A selection of high power resistors. Note the aluminium heatsink and the tab heatsink on the top two resistors.

To get a feel for how a circuit diagram can be read, in Fig.1 we have drawn some electronic components as boxes in a simple diagram. Their terminals are clearly labelled as 1, 2 or 3. The diagram illustrates how lines in a circuit diagram represent conductors, and how to show a *junction* (when conductors are joined together).

First, we can say that components A and B are in *parallel* with each other, because they are connected "across" each other like the rungs of a ladder. Components C and D are in series with each other, because a conductor is used to join terminal 2 of component C to terminal 1 of component D.

Then another part, component E, has been added as shown. Its terminal 1 connects to terminal 1 of components A, B and C, so two blobs (labelled "A" and "B") are used to show that these conductors are all joined together. Terminal 2 of component E is connected with a conductor directly to terminal 3 of component D. Lastly, terminal 3 of E goes directly to terminal 3 of component B.

It is easy to see how lines can therefore be drawn to show how components are linked together with conductors. Note how a blob shows a **joint**, while the *absence* of a blob when lines cross over means the conductors **do not join together**. Therefore, terminal 3 of component E does **not** connect to either C or D; it **only** connects to component B. Pin 2 of Components A, B and D are all joined together, hence the single blob labelled "C".

If we have two components joined directly together (e.g. C and D), we never show the component joints themselves with blobs because it's unnecessary. But when a conductor is joined to another (say by a solder joint or a screw terminal), the junction is clearly signified by a blob. The circuit diagram doesn't usually tell us what sort of wire to use, nor how thick, short or long the conductors should be: you have to read the article to find out.

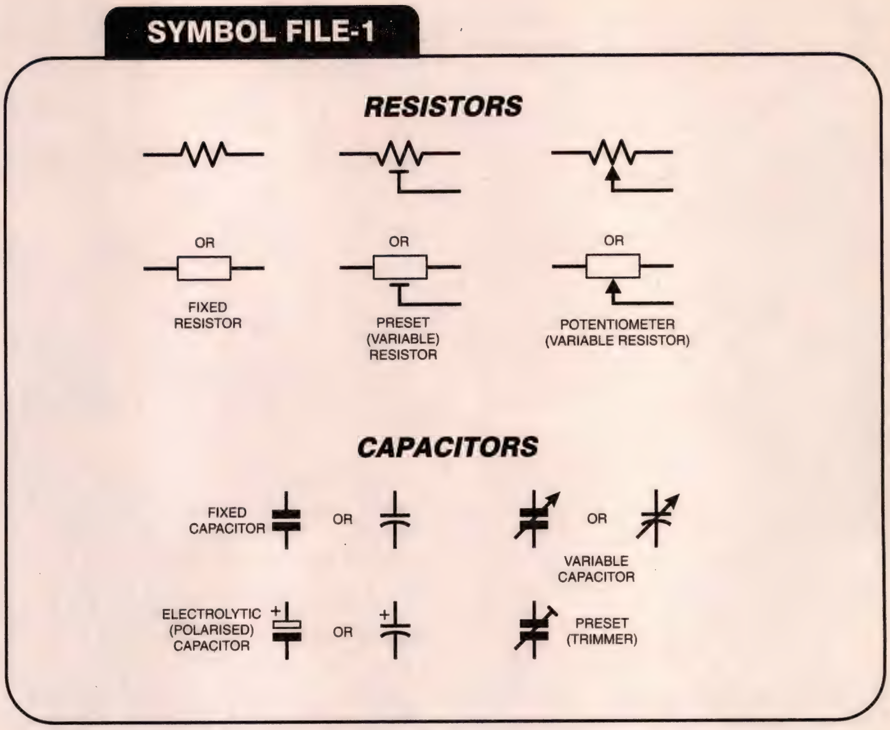


Fig.2. A selection of popular circuit symbols for resistors and capacitors.

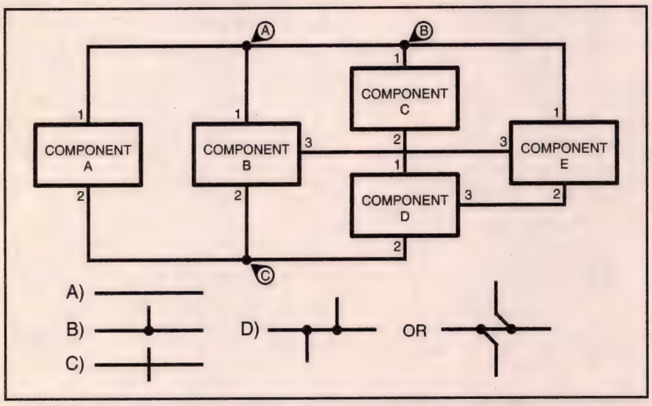


Fig.1. How to read a circuit diagram (see text). (a) conductor, (b) joint, (c) conductors cross but do not join, (d) preferred way of showing off-set multiple conductors joining together.

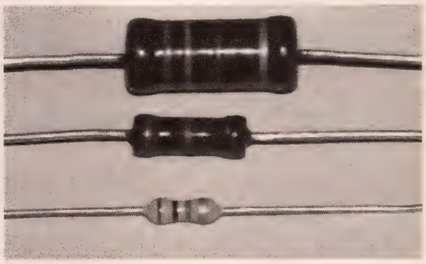
Highway Code

When it comes to describing electronic components themselves – the towns and cities on our road map – then *schematic symbols* are used to represent them in a circuit diagram. In the first of the "File panels", Fig.2, to be included with this mini-series, we have set out some of the circuit symbol options used in *EPE* for resistors and capacitors.

In industry, either American ANSI standards or ISO/British Standard symbols will be seen, so we have shown some common variations. Note that *EPE* always uses the zig-zag symbol for resistors: elsewhere an equally correct rectangle symbol may be used.

Capacitors can also be shown in several ways; *EPE* uses the rectangular version as shown, but elsewhere a curved line is commonly seen, especially on semiconductor data sheets and application notes. Some capacitors are polarity-sensitive, so a plus-sign will be shown accordingly.

Next month, we will illustrate more conventions used in schematic symbols including popular semiconductor devices, possibly looking at more advanced circuit schematics as well. *ARW*

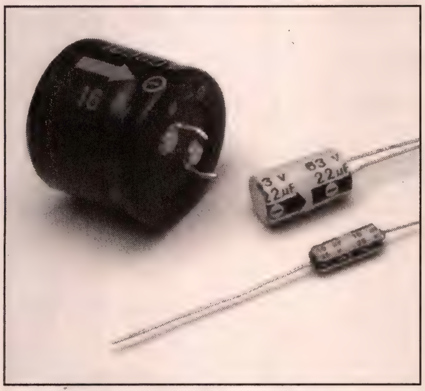


Example fixed carbon film resistors (top to bottom): 1 Watt, 0·25W, 0·5W.

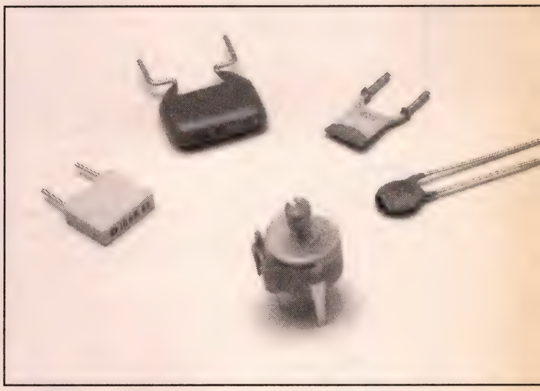
Dream On

Our thanks to ***Noel Harvey*** who emailed us about our 10-part educational series *Teach-In 2002* and our response to an earlier query regarding single supply versions of op.amp circuits. We are pleased to hear that our advice proved to be useful. Noel writes:

Revisiting Teach-In 2002, *thank you for your response to my query* (Circuit Surgery, *Nov '02, page 790) and especially the reference to Ron Mancini's Application Note. Yes, the single sided*



Polarised electrolytic capacitors, first two have "radial" leads and the third "axial".



A small selection of non-polarised capacitors plus a miniature, p.c.b. mounting trimmer capacitor.

supply LM741 was extremely difficult to work with, especially in obtaining d.c. shift.

Changing to the TLV2472 has been a dream come true, no problems with either amplification or d.c. shift. One tip for other readers though, as fixed resistors are only available in widely spaced values, using good quality trimmer resistors in series with them in the feedback and reference voltage circuits enables one to tune the lower and upper amplification limits exactly (250mV and 4·75V in my case).

Regarding sensors though, your input on the following would be appreciated. Assume that one wishes to accurately measure the water level of a pond using a 5 kilohm voltage divider (RS Components Stock No. 319-310 "Rotary Position Sensor"). Obviously, there would be wind driven wavelets (irregular oscillations). Is there a simple method of designing an op.amp circuit to electrically dampen the effect of the ripples, so that the final meter reading is steady, without having to resort to a PIC?

Basically you require a low pass filter. The waves due to the ripples on the pond have a particular frequency (or range of frequencies), but this will be somewhat higher than the rate of variation of water level due to rain or evaporation. To design the filter, you need to know the approximate lowest frequency of troublesome ripples and the highest rate of change in water level that you would be interested in monitoring.

Ripple Effect

The frequency of the ripples relates to the time it takes for the water level to go from a peak to the next peak at a particular location. This is the *period* of the wave; its reciprocal (one divided by this value) gives us the frequency.

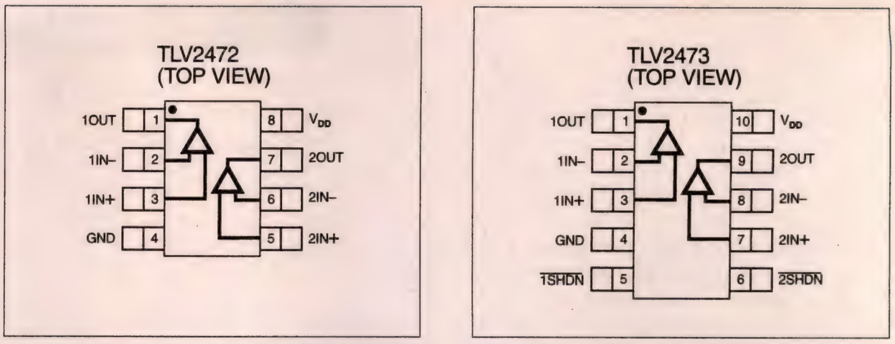


Fig.3. Pinout information for the Texas Instruments TLV2472 dual op.amp and the TLV2473 with a shutdown (SHDN) feature.

As an example, you may observe that the slowest ripples have a period of 4 seconds, or 0·25Hz. Let's assume that the fastest level changes you are interested in would have a cycle time of say 4 hours, which is about 0·00007Hz. Then you need a filter that cuts frequencies above 0·25Hz, but passes those at 0·00007Hz.

As these frequencies are widely separated you do not need a high order filter, and a simple first order *RC* filter should suffice. This filter can be driven from an amplifier or buffered version of the sensor signal, after which you can level shift to the required output range.

Interesting Family

For the benefit of other readers, the TLV2472 is part of a very interesting family of CMOS rail-to-rail op.amps from Texas Instruments. The TLV247x chips contain 1, 2 or 4 op.amps, with each size available with a shutdown option during which the supply current is only 350nA per op.amp on a 3V supply.

The TLV2472 chips operate on supply voltages from 2·7V to 6V, and are low power devices taking only 600μA per op.amp during operation. The outputs can swing to within 180mV of the supplies while driving up to 10mA into the load, and up to 35mA drive is available if rail-to-rail output operation is not required. Both inputs can swing rail-to-rail during normal operation; we covered the importance of this to single supply use in the Nov '02 issue.

Other similar single supply op.amps from Texas include the TLV245x family, which offers lower offsets and lower power consumption, but less bandwidth than the TLV247x chips. Also there is the TLV246x family, which has higher output drive capability. You can learn more by checking the Texas Instruments web site (**www.ti.com**) and search for that part number from their home page.

The pinout of the TLV2472 used by Noel Harvey, which is the twin-op.amp member of the TLV247x family, is shown in Fig.3. Also shown is the TLV2473, which is the version of TLV2472 that has the shutdown (SHDN) controls. *I.M.B.*

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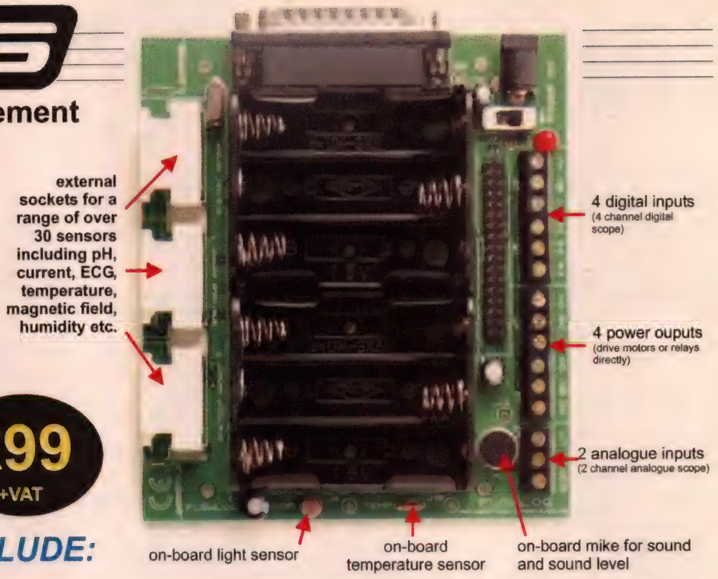
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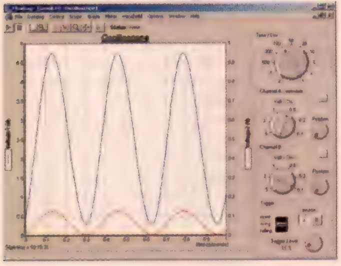

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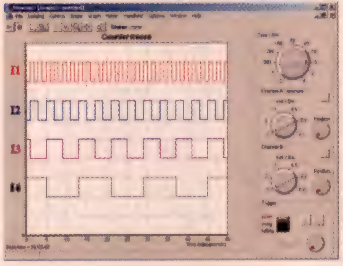

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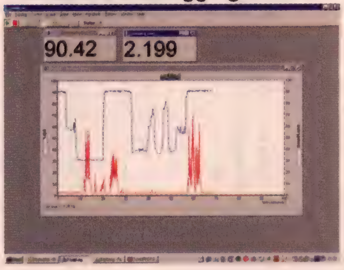

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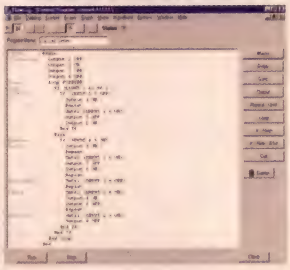

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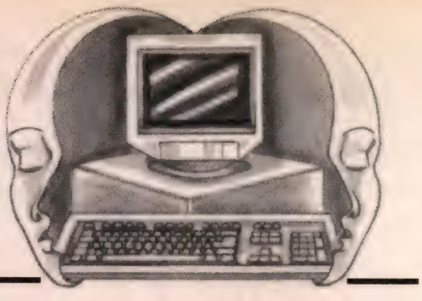


Robert Penfold

UPDATE ON DIRECT CONTROL OF PC SERIAL LINES USING MSCOMM

THE previous *Interface* article covered the subject of using the serial port handshake lines in conjunction with the MSCOMM ActiveX control. This produced a few emails from around the world pointing out that the article had been a bit "economical with the truth". It seems that MSCOMM can indeed do rather more than was suggested in the last article.

Thanks to those who took the time to send in details of the extra facilities that are available. In this article we will try to put the record straight, and provide more details about the use of MSCOMM with the handshake lines.

State Monitoring

As correctly pointed out in the previous *Interface* article, it is possible to count pulses applied via the handshake inputs. They can also be used as edge triggered inputs with certain transitions being detected.

However, it was incorrectly stated that there was no way of reading the state of these lines. It is in fact possible to do so, and for some applications it would be better to use this method of monitoring the handshake inputs.

To be more precise, it is possible to read the input state of three of the handshake inputs. The lines in question are CD (carrier detect), CTS (clear to send), and DSR (data set ready). As far as can be ascertained, there is no facility for reading the state of the RI (Ring Indicator) input.

These input lines are read using the following functions:

Line	*Function*
CD	CDHolding
CTS	CTSHolding
DSR	DSRHolding

All three return True as the value if the relevant line is high (+12V) or False if it is low (–12V).

To try out these functions place a label, MSCOMM, and a timer component onto a form. Make the label quite large, set a large font such as 24 point so that it is easy to see, and delete the default caption in the Properties Inspector.

Use the Properties Inspector to set a short Interval value for the timer component, such as 20ms or 25ms. MSCOMM will use COM1 (serial port 1) by default, so use the Properties Inspector to set the CommPort value at 2 if you wish to use COM2.

CTS Input

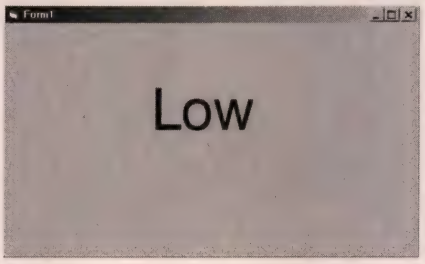
The following two short routines for the form and the timer are all that is needed to make the label show the state on the CTS input:

```
Private Sub Form_Load()
MSComm1.PortOpen = True
End Sub

Private Sub Timer1_Timer()
If MSComm1.CTSHolding = True Then Label1.Caption = “High”
If MSComm1.CTSHolding = False Then Label1.Caption = “Low”
End Sub
```

The single line of code in the subroutine for the form simply switches on the serial port. The routine for the timer uses two If...Then instructions to check the state of the CTS line and set the correct caption on the label component.

The first one sets the caption as "High" if the returned value from CTSHolding is True. The second one sets the caption as "Low" if the returned value is False. As there are only two possible values this could actually be reduced to a single If...Then...Else instruction if preferred.



Low

Fig.1. Unconnected handshake inputs normally drift to the low state.

When the program is run, the label will almost certainly indicate that the CTS input is Low (see Fig.1). Serial port inputs do not usually have any pull-up or pull-down resistors, and simply drift to about zero volts with no input signal.

Practically all serial ports interpret zero volts, or anything less than about one volt, as a low input level. The nominal input levels for an RS232C serial port are ±12V, but applying anything from about +3V to +15V to the CTS input should be sufficient to change the reading on the label to High.

Driving the CTS input with normal logic levels from (say) the parallel port will probably be sufficient to produce a change in the reading from the program. Alternative methods are to use a 9V battery in series with a one kilohm (1k) current limiter resistor, or to simply use one of the serial port's handshake outputs set to the high state. Whatever the signal source, the caption on the label should change to "High", as shown in Fig.2.

Substituting CDHolding or DSRHolding for CTSHolding in the appropriate two lines should make the program respond to the CD and DSR lines respectively. Being able to monitor the state of these three input lines is certainly a useful feature, but it does not necessarily represent the best way of doing things. The method of monitoring described in the previous *Interface* article is often preferable for applications that require pulse counting or a hold-off until a certain transition occurs.

Additional Output

I am grateful to *Muhammad Asim Khan* for pointing out that there is actually a third output available from a PC serial port. There are only two handshake outputs, which are DTR (data terminal ready) and RTS (request to send). However, it is possible to use the TXD (Transmission Data) line to act as a third output.

It can be controlled via MSComm.Break, which is set to True in order to set the TXD line at +12V, or False to set it at –12V. Of course, transmission from this line in the normal manner is not possible if it is controlled directly.

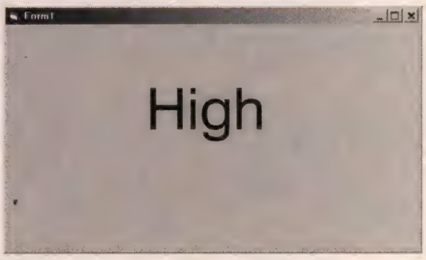
This extended version of the previous program demonstrates the use of this facility:

```
Private Sub Command1_Click()
MSComm1.Break = True
End Sub

Private Sub Command2_Click()
MSComm1.Break = False
End Sub

Private Sub Form_Load()
MSComm1.PortOpen = True
End Sub

Private Sub Timer1_Timer()
If MSComm1.CTSHolding = True Then Label1.Caption = “High”
If MSComm1.CTSHolding = False Then Label1.Caption = “Low”
End Sub
```



High

Fig.2. Taking the CTS input to +9V has produced the correct response from the program.

Two buttons must be added to the form, and these have the captions changed to "High" (Command1) and "Low" (Command 2). The default text size is a bit small so it is advisable to increase the font size to about 18 points. This gives something like Fig.3, which shows the program in operation.

Left-clicking the High button sets MSComm1.Break at True, and the TXD output at +12V. MSComm1.Break is set to False when the Low button is operated, which sets the TXD output at –12V.

The easiest way of checking that the TXD output is changing state is to couple this pin to the CTS input of the serial port. With a 9-pin serial port it is easy to connect these two pins by fitting a miniature crocodile clip over them. Connection details for the 9-pin and 25-pin versions of a PC serial port are shown in Fig.4.

With this link in place, the label's caption should change each time the output state is changed using the two buttons. The label will revert to the default Low reading with the link removed, and the buttons will then have no effect on the label.

Online Library

It is possible to control the state of the TXD output line, so is it possible to read the state of the RXD (Receiver Data) input line? Reader *Jerry McCarthy* provided this useful link to the MSCOMM page of Microsoft's online library:

http://msdn.microsoft.com/library/default.asp?url=/library/en-us/comm98/dt_vbobjComm_P.asp

This page provides a full list of the MSCOMM functions, with a link to a brief description and further information for each one. There does not appear to be anything in the list that permits the RXD input line to be directly monitored.

I have not gone through all the bits of the 16550 UART's registers, but it seems likely that this facility is not in its repertoire. Anyway, four inputs and three outputs might seem meagre compared to the parallel port, but there is still plenty of scope for simple applications such as relay and motor control.

Big Advantage

More ambitious projects should also be possible. With standard UARTs such as the 6402 now "a bit thin on the ground" a simple synchronous interface to serial DACs, ADCs, and shift registers is perhaps a more practical approach than inputting and outputting data in the conventional manner.

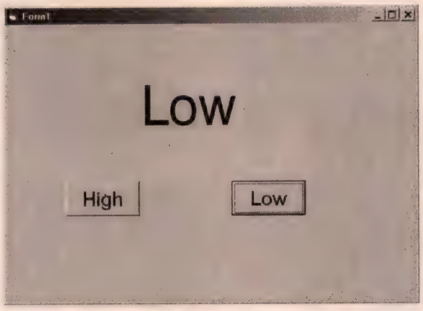


Fig.3. The modified program will read back the level set on the TXD output line.

Interfacing (say) a 12-bit serial DAC and an 8-bit serial ADC to a serial port should not be too difficult. Bear in mind that most modern PCs have two serial ports, neither of which are actually used any more. Two serial ports provide a total of eight inputs and six outputs. Used in the right way, these give massive scope for interfacing projects to a PC.

MSCOMM might have its limitations, but it does have the big advantage of working with any 32-bit version of Windows, including Windows 2000 and XP. With many PCs now supplied with Windows XP rather than Windows ME installed, this is increasingly important. Remember that the MSCOMM ActiveX control must be available to the compiled programs that make use of its facilities. If your version of Visual BASIC came complete with MSCOMM, then you are licensed to use and distribute it with your programs.

Limitation

The main limitation of using MSCOMM and the serial ports is that data cannot be input or output at high speed. High speed serial interfacing requires input/output frequencies of many megahertz. Ordinary serial chips and line drivers/receivers are not intended for operation at anything approaching that sort of rate.

An RS232C serial port can output data at up to about 10 kilobytes or so per second when used conventionally. It might be possible to go slightly higher than this when using the handshake lines in a synchronous serial link, but a vast improvement is unlikely. Fortunately, there are many applications that do not require transfers at more than about 10 or 20 kilobytes per second.

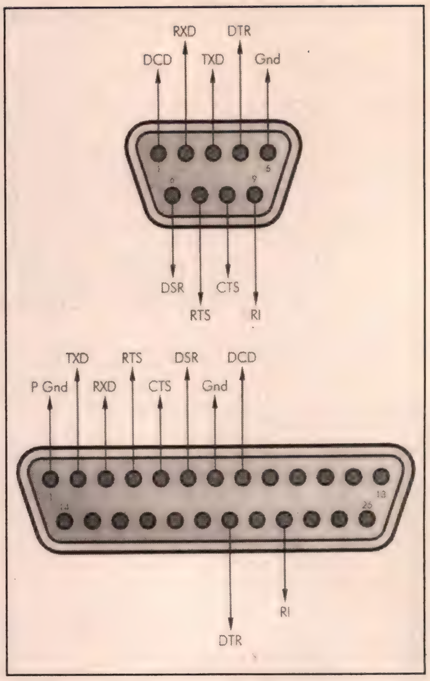


Fig.4. Connection details for 9-pin and 25-pin PC serial ports.

Ordinary logic outputs will usually drive RS232C inputs successfully. At worst the add-on will simply fail to work.

When designing serial port projects it is essential to bear in mind that the output voltages from an RS232C could potentially zap many devices that are intended for use with 5V logic levels. Also, bear in mind that the actual output voltages can be somewhat more than the nominal ±12V volt levels, which are more than adequate to damage many logic chips anyway.

Interfacing the serial port lines to ADCs and other devices that operate at normal logic levels will be covered in the next *Interface* article.

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24V, 750W	£88.23
12V, 500W*	£74.97
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PART ONE

Quite simply the easiest low-cost way to learn about using PIC Microcontrollers!

WHAT IT'S ALL ABOUT

At the time that the original *EPE PIC Tutorial* was published in March to May 1998, letters and phone calls to *EPE* had been showing that interest in Microchip's PIC microcontrollers had become intense. Many readers were asking for more information on how to use these devices in designs of their own invention.

In the words of one reader, "I find the PIC data sheets too skimping on everyday detail, and the published software too complex. Please show me how to get to grips with the *essence* of PICs. Tell me, step-by-step, how to get started with writing simple programs, how to just turn on a single light emitting diode, for example. Then take me forward from there."

It was to meet this demand that the original *EPE PIC Tutorial* was published. Its success resulted in a CD-ROM version being produced commercially as *PICtutor*, complete with its own ready-built development board. Recently that version was upgraded to become *Assembly for PICmicro V2* along with its Version 2 PICmicro MCU board (see elsewhere in *EPE* for details). Many thousands of people have learned to program PICs through these several versions.

However, we frequently receive requests from readers for PIC programming education that is available at minimal cost. The aim of this three-part *EPE PIC Tutorial V2* series is to do just that, as detailed more fully on the next two pages. In a nutshell, though, it gets you inexpensively started with PICs, and does so "step-by-step".

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THIS REVISION

Over five years on from the publication of the original *EPE PIC Tutorial*, a number of things have changed, yet at the same time the basics of programming PIC microcontrollers have not.

This revision is thus a mixture of the old and the new. The old aspect is that the commands used to program PICs remain the same. The new aspects, though, are several:

The original *EPE PIC Tutorial* illustrated its example programs in a programming dialect known as TASM. This dialect is usable with a variety of tables whose contents can be modified to suit many types of microcontroller and microprocessor. It had been modified to suit PICs by reader Darren Crome.

This revision now has its programming examples written in Microchip's own PIC programming dialect, MPASM. This dialect is the "industry standard" and thus has far wider appeal than TASM, although the basic differences between the two are slight.

Secondly, the original *EPE PIC Tutorial* concentrated on the now-obsolete PIC16C84 as being the target device. This microcontroller effectively became replaced in 1997 by the pin-for-pin compatible PIC16F84, which is an equally excellent device to use to illustrate PIC programming techniques. More recently the PIC16F84A has arrived on the scene. The PIC16F84 and PIC16F84A (two of the devices in the PIC16F8x family) can be used interchangeably in this *EPE PIC Tutorial V2* (referred to from now on as the *Tutorial*).

FAMILY MATTERS

Once you know how to program a PIC16F84 you are well equipped to write programs for other PICs, although there are some minor differences in the way that the various PIC families handle some of the same functions.

Apart from the PIC16F8x family, two other PIC families are eminently suited to hobbyist constructors, notably the PIC16F87x and PIC16F62x families (although they are not immediately suited to this *Tutorial*). However, in the final part of this three part series, basic differences between the way that the PIC16F8x, PIC16F87x and PIC16F62x families do the same thing are highlighted and the Tutorial programs can be readily modified to run on these devices. Examples of some useful routines specific to the PIC16F87x family are included.

It is stressed, though that this *Tutorial* does not attempt to be a full tutorial on every aspect of the three families. Nor does it examine specific aspects of some other PIC families whose functions are more advanced than most readers probably require.

Also, the *Tutorial* does not teach the use of Microchip's MPASM and MPLAB programming software, and it does not cover any PIC variant or dialect that is programmed in versions of BASIC.

An important aspect of this revision is that it has been designed for use with the *EPE PIC Toolkit TK3* printed circuit board and software (published Oct/Nov 2001), both of which, plus their two texts, you need in order to get full benefit from this *Tutorial*. See the Resources panel for details of obtaining them. Note that these are included on the *EPE PIC Resources CD-ROM*. From hereon the software and p.c.b. are jointly referred to simply as *TK3*.

RESOURCES

A special composite *EPE PIC Resources CD-ROM* has been produced to accompany this series. It includes the *Tutorial* software for the entire series, *EPE Toolkit TK3* software, complete reproductions of the *TK3* texts of Oct/Nov '01, *Using TK3 with Windows XP and 2000* (Oct '02) and a broad selection of PIC-related articles published in *EPE* over the last several years and which illustrate practical examples of various advanced programming functions and techniques. Some unpublished articles are included as well. The full list is given elsewhere in *EPE*.

Alternatively, software for *TK3* and this *Tutorial* can be downloaded *free* from the *EPE* FTP Site. Disks for both sets of software (CD-ROM for *TK3*, and 3.5in disk for this *Tutorial*) are also available from the *EPE* Editorial Office. Back issues (or photocopies) or Back Issue CD-ROMs of published texts can also be purchased (see the *Back Issues* page).

The *EPE* FTP Site is most easily accessed via the main page at **www.epemag.wimborne.co.uk**. Click on the *FTP Site (Downloads)* option at the top, then click down the paths **pub/PICS** then select *PIC Tutorial V2* or *Toolkit TK3*.

The printed circuit board for *TK3* is available from the *EPE PCB Service*, code 319. Note, you will require the relevant back issues or the *EPE PIC Resources CD-ROM* to be able too build this.

See the *EPE PCB Service* page for the price and ordering details of the disks and p.c.b.

It should be noted that *TK3* was written to run under Windows 95, 98 and ME. To run it under Windows NT, XP and 2000 the software must be used as described in Mark Jones' article *Using TK3 with Windows XP and 2000* of Oct '02. This article is also carried on the *EPE PIC Resources CD-ROM*.

In keeping with the original *Tutorial*, we assume in this series that you have no previous knowledge of PICs and their programming. We thus start as we did before, by explaining the basic nature of a PIC microcontroller.

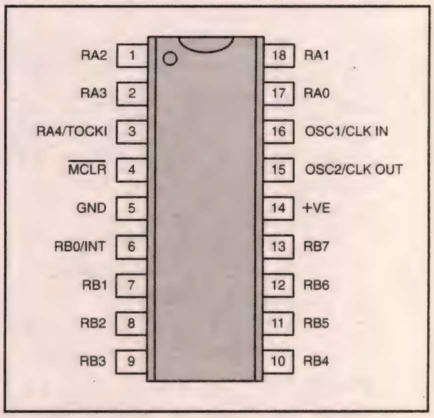

Fig.1. Pinouts for the PIC16F8x family.

WHAT IS A PIC?

A PIC chip, in this context, is a microcontroller integrated circuit manufactured by Microchip. When asked about the name's origin, Microchip's Technical Department

BASIC PIC16F84 SPECIFICATIONS

35 single-word commands (see Table 1)
1K × 14-bit EEPROM program memory
68 × 8-bit general purpose SRAM registers
15 special function hardware registers (see Table 2 later)
64 × 8-bit EEPROM data memory
1000 program memory erase/write cycles (typical)
10,000,000 data memory erase/write cycles (typical)
Data retention >40 years
5 data input/output pins, Port A
8 data input/output pins, Port B
25mA current sink maximum per pin
20mA current source maximum per pin
80mA maximum current sunk by Port A
50mA maximum current sourced by Port A
150mA maximum current sunk by Port B
100mA maximum current sourced by Port B
Total power dissipation 800mW
8-bit timer/counter with 8-bit prescaler
Power-on reset (POR)
Power-up timer (PWRT)
Oscillator start-up timer (OST)
Watchdog timer (WDT) with own on-chip RC oscillator
Power saving Sleep function
Code protection
Serial in-system programming
Selectable oscillator options:
RC: low cost RC oscillator
XT: standard crystal/resonator (100kHz to 4MHz)
HS: high speed crystal/resonator (4MHz to 10MHz) (to 20MHz for 'F84A)
LP: power-saving low frequency crystal (32kHz to 200kHz)
Interrupts:
External, RB0/INT pin
TMR0 timer overflow
Port B RB4 to RB7 interrupt on change
Data EEPROM write complete
Operating voltage range: 2·0V to 6·0V (to 5·5V for 'F84A)
Power consumption:
<2mA @ 5V, 4MHz
15μA typical @ 2V, 32kHz
<1μA typical standby @ 2V

TUTORIAL CONCEPTS EXAMINED

TUTORIAL 1:
Minimum commands needed
Port default values
Instruction ORG
Instruction END
Command GOTO
Program TK3TUT1.ASM

TUTORIAL 2:
Clock cycles
File registers
Bits
Bytes
Set
Clear
Command CLRF
Command CLRW
Command BSF
Command BCF
Ports and Port directions
Register STATUS
STATUS register bit 5
Banks 0 and 1
Program TK3TUT2.ASM

TUTORIAL 3:
Names in place of numbers
Case sensitivity
Labels
Repetitive loop
Instruction EQU
Program TK3TUT3.ASM

TUTORIAL 4:
Command MOVLW
Command MOVWF
Command RLF
Command RRF
Command BTFSS
Command BTFSC
Instruction #DEFINE
Instruction BANK0
Instruction BANK1
Register PORTA
Register TRISA
Register PORTB
Register TRISB
Register PCL
Naming numbers
Bit naming
Program counter
STATUS register bit 0
Carry flag
Bit codes C, F, W
Bit testing
Conditional loop
Pin protection
Program TK3TUT4.ASM
Program TK3TUT5.ASM

TUTORIAL 5:
STATUS bit 2
Zero flag
Bit code Z
Command MOVF
Program TK3TUT6.ASM

TUTORIAL 6:
Command INCF
Command DECF
Command INCFSZ
Command DECFSZ
Counting upwards (incrementing)
Counting downwards (decrementing)
Use of a file as a counter
Program TK3TUT7.ASM

TUTORIAL 7:
Switch monitoring
Command ANDLW
Command ANDWF
Command ADDWF
Command ADDLW
Nibbles
STATUS bit 1
Digit Carry flag
Bit code DC
Program TK3TUT8.ASM

TUTORIAL 8:
Increasing speed of TK3TUT8
Bit testing for switch status
Program TK3TUT9.ASM

TUTORIAL 9:
Responding to a switch press only at the moment of pressing
Program TK3TUT10.ASM

TUTORIAL 10:
Performing functions dependent upon which switch is pressed
Use of a common routine serving two functions
Program TK3TUT11.ASM

TUTORIAL 11:
Reflecting PORTA's switches on PORTB's l.e.d.s
Command COMF
Command SWAPF
Inverting a byte's bit logic
Swapping a byte's nibbles
Program TK3TUT12.ASM
Program TK3TUT13.ASM
Program TK3TUT14.ASM

TUTORIAL 12:
Generating an output frequency in response to a switch press
The use of two port bits set to different input/output modes
Command NOP
Program TK3TUT15.ASM

TUTORIAL 13:
Command CALL
Command RETURN
Command RETLW
Program TK3TUT16.ASM

TUTORIAL 14:
Tables
Register PCL (again)
Register PCLATH
Program TK3TUT17.ASM

TUTORIAL 15:
Using four switches to create four different notes
Use of a table to selectively route program flow
Program TK3TUT18.ASM

TUTORIAL 16:
Indirect addressing
Using unnamed file locations
Register FSR
Register INDF
Program TK3TUT19.ASM

TUTORIAL 17:
Tone modulation
Command XORLW
Command XORWF
Command IORLW
Command IORWF
Program TK3TUT20.ASM
Program TK3TUT21.ASM
Program TK3TUT22.ASM

TUTORIAL 18:
Register OPTION
Register INTCON
Register TMR0
Use of internal timer
Program TK3TUT23.ASM

TUTORIAL 19:
BCD (Binary Coded Decimal) counting
Program TK3TUT24.ASM

TUTORIAL 20:
Real-time timing at 1/25th second
Counting seconds 0 to 60
Program TK3TUT25.ASM

TUTORIAL 21:
Using 7-segment l.e.d. displays
Showing hours, minutes and seconds
Command IORLW (usage)
Program TK3TUT26.ASM
Program TK3TUT27.ASM
Program TK3TUT28.ASM

TUTORIAL 22:
Using intelligent l.c.d.s
Setting l.c.d. contrast
Initialising the l.c.d.
Sending a message to the l.c.d.
Program TK3TUT29.ASM

TUTORIAL 23:
Coding hours, minutes and seconds for an l.c.d.
Shortened clock monitoring code
Command SUBLW
Command SUBWF
Program TK3TUT30.ASM

TUTORIAL 24:
Adding time-setting switches
Program TK3TUT31.ASM

TUTORIAL 25:
Writing and reading EEPROM file data
Register EECON1
Register EECON2
Register EEDATA
Register EEADR
Program TK3TUT32.ASM

TUTORIAL 26:
Illustrating use of EEPROM data read/write
Converting binary value to hexadecimal
Program TK3TUT33.ASM

TUTORIAL 27:
Interrupts
Command RETFIE
Program TK3TUT34.ASM
Program TK3TUT35.ASM

TUTORIAL 28:
Command SLEEP
Program TK3TUT36.ASM

TUTORIAL 29:
Watchdog timer (WDT)
Command CLRWDT
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TUTORIAL 30:
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TUTORIAL 31:
INCLUDE files command
Embedded configuration data
Embedded Data EEPROM values
Embedded PIC type data
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Program TK3TUT38.ASM

TUTORIAL 32:
PIC16F8x, PIC16F87x, PIC16F62x family coding differences
PIC16F87x PORTA
PIC16F87x Data EEPROM use
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PIC16F62x Data EEPROM use
Program TK3TUT39.ASM
Program TK3TUT40.ASM

TUTORIAL 33:
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TUTORIAL 34:
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Program TK3TUT42.ASM

TUTORIAL 35:
Division routine
Program TK3TUT43.ASM

TUTORIAL 36:
ADC conversion routine for PIC16F87x family
Program TK3TUT44.ASM

TUTORIAL 37:
CBLOCK command
Interfacing to external serial EEPROM chips, for PIC16F87x family
Program TK3TUT45.ASM

TUTORIAL 38:
Outputting serial data at a specified BAUD rate, for PIC16F87x family
Program TK3TUT46.ASM

TUTORIAL 39:
Practical example recording analogue data to serial EEPROM and subsequent outputting as RS-232 serial data
Program TK3TUT47.ASM

TUTORIAL 40:
Programming PICs vs. hardware
Summing-up

APPENDIX A:
Bugged Teaser!

APPENDIX B:
Useful PIC information
Further reading

replied, *"PIC is not an acronym; it is just a trademarked name that General Instruments came up with a long time ago"*. (GI were the originators of PICs.)

A microcontroller is similar to a microprocessor but it additionally contains its own program command code memory, data storage memory, bi-directional (input/output) ports and a clock oscillator. Many microprocessors require the use of additional chips to provide these requirements; microcontrollers are totally self-contained.

The great advantage of microcontrollers is that they can be programmed to perform many functions for which many other chips would normally be required. This not only makes for simplicity in electronic designs, but also allows some functions to be performed which could not be done using normal digital logic chips – i.e. circuits for which, previously, a microprocessor and peripheral devices would have been required.

PICs are manufactured and supplied "empty". That is, they are without program codes (commands) and cannot control a circuit until they have been provided with a program that tells them what to do. It is the task of the program writer (you) to tell them what that is.

The commands are written in a specialised form of English, largely consisting of mnemonics, known as the "source code". An assembly program (such as *TK3*) then translates (assembles) the source code commands into a numerical form that the PIC can understand, the "program code". This code, which is normally in hexadecimal, is then sent (loaded) in binary format to the PIC by electronic hardware, such as *TK3*'s p.c.b.

PIC VARIETIES

There are many families of PIC microcontroller available, ranging from those which can only be programmed once, to those that can be repeatedly reprogrammed. The former are typically known as One Time Programmable (OTP) devices, and because of this characteristic are not well-suited to hobbyist use since they cannot have their software code changed once they have been programmed.

There are two basic families of reprogrammable PICs: those that require an ultra-violet light unit to erase their previous data before being reprogrammed, but which are now essentially obsolete, and those which are electrically erasable.

In the latter category fall the three device families already mentioned, of which it is the PIC16F84 device we use here. It has been chosen because of its ease of reprogramming and because it does not have additional features that can prove difficult to understand for beginners. Its pinouts are shown in Fig.1, and its basic attributes given in the Specifications panel.

It is an EEPROM (electrically erasable programmable read only memory) device, also known as a "Flash" device, hence the "F" infix in its type number. This means that it can be rapidly reprogrammed as often as you wish, without the need for ultra-violet erasing.

SUB-VERSIONS

Note that there are several sub-versions of individual PIC types, having suffixes such as -04, -10 and -20. The suffix indicates the maximum clock rate at which the chip can be used: 4MHz, 10MHz and 20MHz respectively. You may use any device speed rating for this *Tutorial*, although the -04 is likely to be stocked by more component suppliers.

TABLE 1. PIC COMMAND CODES FOR PIC16F8x, PIC16F87x AND PIC16F62x

Command/Syntax		*Flags affected*	*Cycles*	*Description*	*Tutorial discussed*
BYTE-ORIENTATED FILE REGISTER OPERATIONS					
ADDWF	f,d	C, DC, Z	1	Add W and f	7
ANDWF	f,d	Z	1	AND W with f	7
CLRF	f	Z	1	Clear f	2
CLRW	–	Z	1	Clear W	2
COMF	f,d	Z	1	Complement f	11
DECF	f,d	Z	1	Decrement f	6
DECFSZ	f,d	–	1 (2)	Decrement f, skip if 0	6
INCF	f,d	Z	1	Increment f	6
INCFSZ	f,d	–	1 (2)	Increment f, skip if 0	6
IORWF	f,d	Z	1	Inclusive OR W with f	17
MOVF	f,d	Z	1	Move f	5
MOVWF	f	–	1	Move W to f	4
NOP	–	–	1	No operation	12
RLF	f,d	C	1	Rotate left f through Carry	4
RRF	f,d	C	1	Rotate right f through Carry	4
SUBWF	f,d	C, DC, Z	1	Subtract W from f	23
SWAPF	f,d	–	1	Swap nibbles in f	11
XORWF	f,d	Z	1	Exclusive OR W with f	17
BIT-ORIENTATED REGISTER OPERATIONS					
BCF	f,b	–	1	Bit clear f	2
BSF	f,b	–	1	Bit set f	2
BTFSC	f,b	–	1 (2)	Bit test f, skip if 0	4
BTFSS	f,b	–	1 (2)	Bit test f, skip if 1	4
LITERAL AND CONTROL OPERATIONS					
ADDLW	k	C, DC, Z	1	Add literal and W	7
ANDLW	k	Z	1	AND literal with W	7
CALL	k	–	2	Call subroutine	13
CLRWDT	–	TO, PD	1	Clear Watchdog Timer	29
GOTO	k	–	2	Go to address	1
IORLW	k	Z	1	Inclusive OR literal with W	17, 21
MOVLW	k	–	1	Move literal to W	4
RETFIE	–	–	2	Return from interrupt	27
RETLW	k	–	2	Return with literal in W	13
RETURN	–	–	2	Return from subroutine	13
SLEEP	–	TO, PD	1	Go into standby mode	28
SUBLW	k	C, DC, Z	1	Subtract W from literal	23
XORLW	k	Z	1	Exclusive OR literal with W	17

The PIC16F84 used here has two input/output (I/O) ports, Port A and Port B. Port A has five pins (RA0 to RA4), and Port B has eight pins (RB0 to RB7). We shall be using the PIC in two of its four oscillator modes, RC (resistor/capacitor) and XT (standard crystal up to 4MHz), the former being variable, the latter using a 3·2768MHz crystal.

To re-emphasise an earlier point, much of the information about the commands which we present here is, in most instances, applicable to other members of the PIC family. Once you understand a PIC16F84 you should have no difficulty applying your knowledge to other PICs.

WHAT YOU NEED

There are six things that you need in order to program a PIC:

- PC-compatible computer having a standard (Centronics-compatible) parallel printer port (USB ports are not suitable)
- purpose built programming hardware board (e.g. *TK3*)
- standard (Centronics) parallel printer port connecting cable
- suitable power supply (*TK3* runs from 9V d.c., which can be supplied via a plug-in mains adaptor)
- word-processing program (text editor)
- assembly and send (download) software program (e.g. *TK3*)

It is worth noting that this *Tutorial* and the *TK3* software can be used with Magenta's version of the *TK3* board, and with the commercial Version 2 PICmicro MCU Development Board. However, these two boards do not have the numbered CP connection points referred to in this text regarding the *EPE TK3* board, but they do have pin function notations and the connections should be obvious.

Data is output from the computer to the PIC via the parallel printer port (addresses 378h, 278h and 3BCh are supported by *TK3*). It is output serially, data on port line D0, and a clock signal on line D1. Additional computer printer port lines are used by *TK3* to enable such functions as reading back program code from a PIC.

You must be able to use a word-processing program. This must produce a text file that is totally without formatting and printer commands. That is, it must be able to generate a pure ASCII text file (and to input one). It is stressed that the source code (.ASM) files *must* be in pure ASCII text formats without printer or display format commands embedded in them. (*TK3* offers a choice of editors, including DOS Edit, Windows Notepad and Windows Wordpad.)

ADDITIONAL COMPONENTS

To use this *Tutorial* with the basic *TK3* p.c.b. you need the following additional components:

330Ω resistor, 0·25W 5% carbon film (8 off)

1µF capacitor, axial elect. 10V

2-line, 16-characters per line alphanumeric liquid crystal display module and datasheet

Optional: 4-digit multiplexed common cathode 7-segment l.e.d. display module and datasheet

Personal (high-impedance) headphones

Jack socket to suit headphones

Extra push-to-make switch for connection via flying leads

Stranded connecting wire

Solder

ANOTHER NEED

Throughout this *Tutorial* we shall examine in a fair amount of detail the 35 basic PIC commands. It is hoped that this will give you all the necessary information that will enable you to conceive a design in which you can use a PIC16F84 to control whatever situation you wish, and to write the code that will let it do so.

There is, though, much more to writing programs than you may at this moment fully appreciate. Knowledge about individual commands and the way in which they can be used is not enough in itself.

Programming is a way of looking at the world that other people may not recognise. You must have the mental ability to see each programming situation as a step by step function, visualising and analysing in your mind exactly how it is that you need to specify the complete program flow.

You have to write the sequence of events with the correct grammar, with the correct spelling and in the correct order. Undoubtedly you will make mistakes while you are writing the code, failing to see the correct sequence of events and using incorrect command structures.

You require the ability to analyse what you have done wrong and to correct it. You are likely to be confronted with an overall task that may, on occasion, take you into several days or even weeks of dedicated concentration.

Readers have occasionally asked how they can be taught to think like a programmer. There is no easy way in which this can be taught. Some people have the ability, some do not. The best way to learn is by actually writing snippets of code and get those to work, giving you the experience and confidence to progress to more complex situations. Throughout this *Tutorial* we try to encourage you in this approach.

Programming, to those who have the ability to see things "as they are" and not "how they seem to be", can become extremely addictive. You could find yourself compelled to get back to the keyboard and PIC programmer at any conceivable hour. You had better have an understanding family!

FIRST THINGS FIRST

To get you started programming PICs through this *Tutorial*, you need the *TK3* board mentioned earlier plus the few extra components just listed. *TK3* already has eight light emitting diodes (l.e.d.s), four pushbutton switches and four uncommitted (open-collector) *npn* transistors.

These facilities help to illustrate the program examples discussed in the text and encourage you to build up your experience of how the PIC16F84 can be made to respond to different practical situations.

In this text, we start at the very beginning of programming. The first lesson is about the very minimum of information that needs to be written into a program listing before the PIC can do anything else.

We then, "step by step", take a specific very simple task, such as turning on an l.e.d., and describe in detail each of the commands that are required to do the task.

Having described one task, we then take that idea a stage further, adding a few more commands that will enhance the capabilities of the program. Each of these commands is similarly discussed in detail. Thus we progress, taking simple ideas, and illustrating how they can be achieved and then enhanced.

We feel that this approach is far more useful than describing each and every one of the commands in turn before we ever get to use them. Most people learn by doing, reading about things in short sections and applying the knowledge in practical bite-sized chunks. A complete chapter on all the commands in sequence would be too much to remember and understand in one go.

The complete list of Microchip's commands for the PIC16F8x, PIC16F87x and PIC16F62x families is shown in Table 1. All are discussed and demonstrated. In the early years of PICs there used to be two others, OPTION and TRIS, but Microchip have dropped them from their recent PIC families.

As you will see, there are a lot of "bit-orientated" sub-commands available as well as the main commands. Some of these are similar in operation and close examination will be given only to the principal ones – once you understand these, use of the similar bit-setting commands available will become obvious.

TUTORIAL SECTIONS

The *Tutorial* is split into numbered sections. Each deals with specific coding topics but, in most cases, is a direct follow-on from the previous one, and is nearly always visually illustrated by the displays on the *TK3* p.c.b. The exception to the latter is when sound is used as the output medium, when the personal headphones are needed.

At the end of most sections there are a few simple exercises which allow you to experiment with the program presented in that section. You will only be expected to use the commands that have already been introduced to you. None of them should tax your brain too much, but they will, hopefully, encourage you to think of alternative ways in which the same basic task can be tackled, or to consider other tasks that can be achieved using similar techniques.

By the end of the complete *Tutorial*, you will know how to get the PIC16F84 to respond to switches and other external signal sources, send data to various types of display, to create sound, to be the heart of a 24-hour clock and to store data in its non-volatile EEPROM memory.

Readers who have had experience of programming in BASIC, or with other types of microprocessor or microcontroller, will find that once a few commands have had their functions explained, using them will rapidly become instinctive. The author, having many years of such experience, effectively learned about PICs and how to use them over a single weekend, just by doing a bit of experimenting.

Other readers without such experience will, it has to be said, have to become accustomed to understanding programming itself as a step by step process. An analytical mind is required and, as said earlier, there is no easy way in which programming can be taught to those who lack this ability.

TUTORIAL EXERCISES

Throughout this *Tutorial* we present various programming exercises at which to try your hand. In most cases, you are requested to modify an existing tutorial program. This requires it to be saved, assembled and sent to the PIC.

It is important that when you make these changes, you do not save the variant under the same name as the original. It must have a different name. If you *do* save under the same name, the original file will be replaced by the new one. You can save each program variant by any name of your choosing, but use the same .ASM extension as the examples use. You might consider using TRY1.ASM, TRY2.ASM, etc.

It is recommended that you save the original file under the new name before you make any changes, to avoid curse-worthy errors! But if you do make a mistake and overwrite something you should not, the original can be recopied from its disk or FTP site download.

Having saved your changed file, you now assemble and send it to the PIC.

We shall *not* be giving possible solutions (of which there could be several) to any of the exercise questions. It is expected that you will persevere until you find a workable solution. Only in this way will you get into the habit of being presented with a computing problem, which you have to solve on your own, and then solving it.

This last statement was made in the original *Tutorial* text but we still periodically get asked what the solutions are. We are hard-hearted on this point and don't offer solutions! If you want to become a programmer, you've got to get your brain thinking like one. The exercises are all simple and have simple solutions, we would not be doing you any favour by telling you some answers.

We are now almost in a position to start telling you about writing programs for a PIC16F84 and for you to start getting your brain into gear – it's really all very logical!

PREPARATION

From hereon you need the *TK3* software running on your PC. It should be loaded and run as explained in its published text. You also need the *TK3* p.c.b. connected to the PC via its parallel printer port cable, and a PIC16F84 in the allocated socket. You do not need the l.c.d. or 7-segment l.e.d. modules connected at this time. However, if the l.c.d. module is already connected you do not need to remove it.

All the software for this *Tutorial* should be in the same folder. This may be the same folder as used for *TK3*'s software, or in

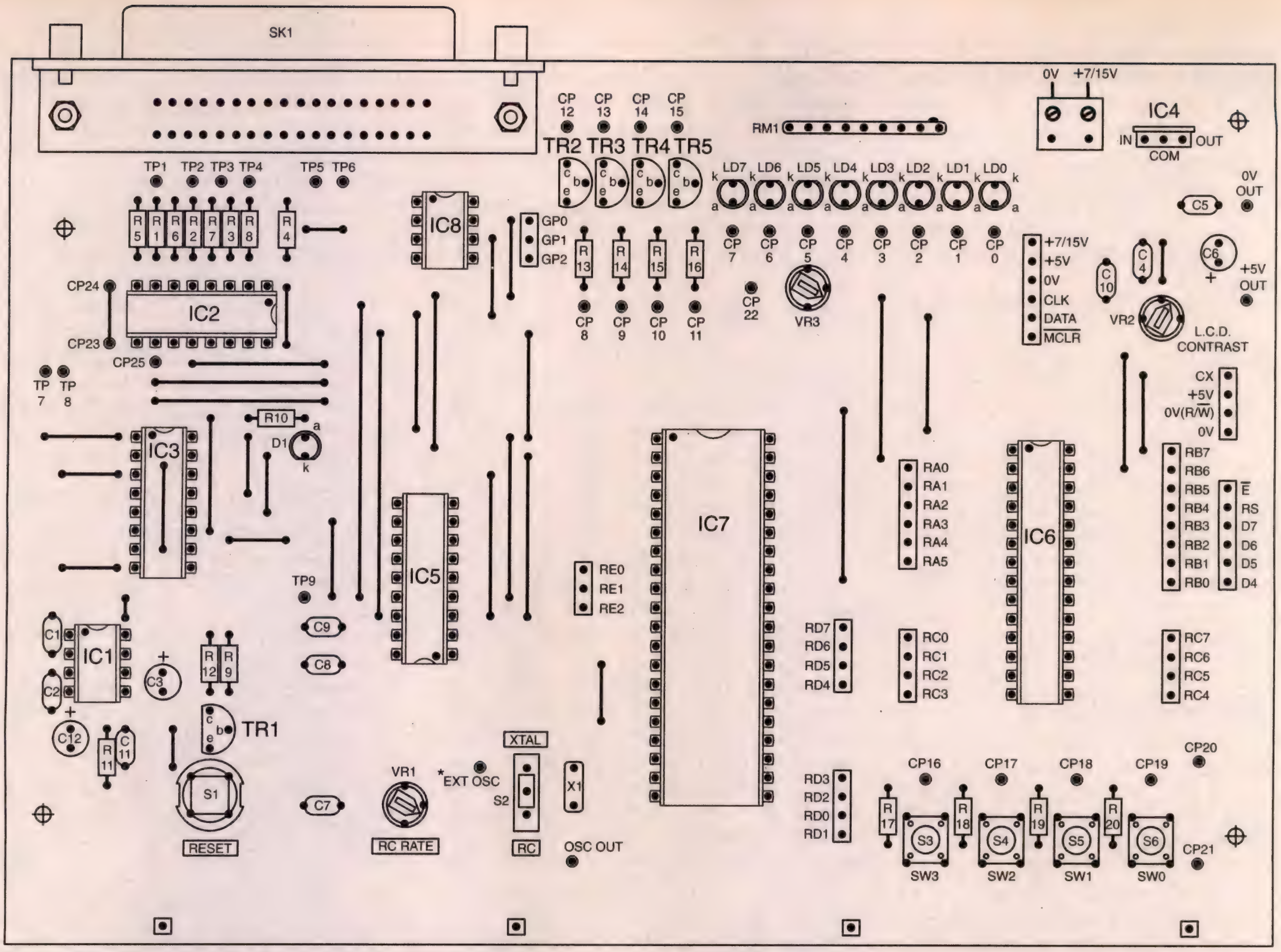
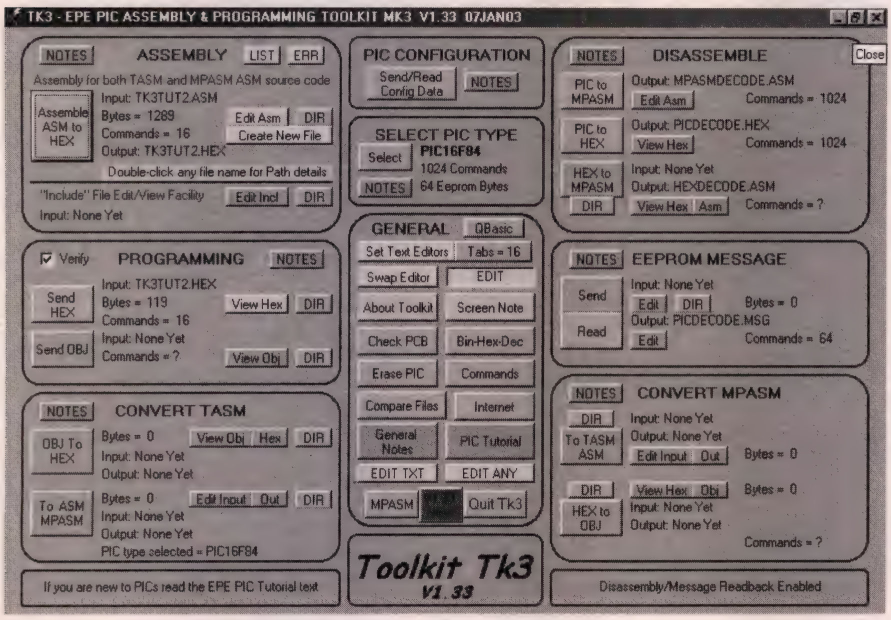


Fig.2. Component layout for the TK3 *board to which you should refer for the connection points required for the exercises.*


TK3 - EPE PIC ASSEMBLY & PROGRAMMING TOOLKIT MK3 V1.33 07JAN03

ASSEMBLY

Assembly for both TASM and MPASM ASM source code

Input: TK3TUT2.ASM
Bytes = 1289
Commands = 16
Output: TK3TUT2.HEX

Double-click any file name for Path details

"Include" File Edit/View Facility
Input: None Yet

PROGRAMMING

☑ Verify

Input: TK3TUT2.HEX
Bytes = 119
Commands = 16
Input: None Yet
Commands = ?

CONVERT TASM

Bytes = 0
Input: None Yet
Output: None Yet

Bytes = 0
Input: None Yet
Output: None Yet
PIC type selected = PIC16F84

If you are new to PICs read the EPE PIC Tutorial text

PIC CONFIGURATION

SELECT PIC TYPE

PIC16F84
1024 Commands
64 Eeprom Bytes

GENERAL

Tabs = 16

Toolkit Tk3
V1.33

DISASSEMBLE

Output: MPASMDECODE.ASM
Commands = 1024
Output: PICDECODE.HEX
Commands = 1024
Input: None Yet
Output: HEXDECODE.ASM
Commands = ?

EEPROM MESSAGE

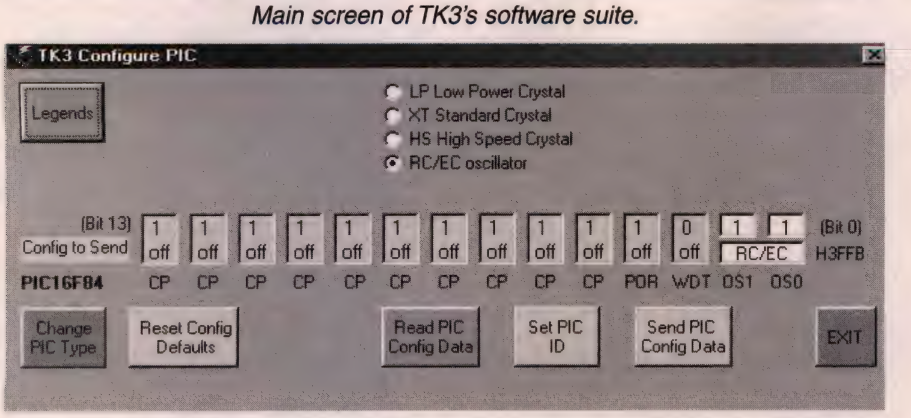
Input: None Yet
Bytes = 0
Output: PICDECODE.MSG
Commands = 64

CONVERT MPASM

Input: None Yet
Output: None Yet
Bytes = 0
Bytes = 0
Input: None Yet
Output: None Yet
Commands = ?

Disassembly/Message Readback Enabled

Main screen of TK3's software suite.


TK3 Configure PIC

○ LP Low Power Crystal
○ XT Standard Crystal
○ HS High Speed Crystal
● RC/EC oscillator

(Bit 13)													(Bit 0)	
Config to Send	1 off	1 off	1 off	1 off	1 off	1 off	1 off	1 off	1 off	1 off	1 off	0 off	1 RC/EC	1	H3FFB
PIC16F84	CP	CP	CP	CP	CP	CP	CP	CP	CP	CP	POR	WDT	OS1	OS0	

Configuration settings used for the first several experiments, putting the PIC16F84 into RC oscillator mode.

another folder having any name of your choosing. There is no "installation" required, just copy the files into this folder from your disk or FTP site download, using Windows' own copying facilities.

As we progress, you need to connect various PIC pins to such on-board items as l.e.d.s and switches. This will be explained as required. In the meantime, keep your soldering iron switched on and ready! Remember that you should always switch off *TK3*'s power *before* making any soldered changes. It is also recommended that the printer port cable should be disconnected at this time as well.

The first few Tutorials require PIC Port B to control the eight l.e.d.s (LD0 to LD7) on *TK3*'s board (see Fig.2). Solder short lengths of wire between the allocated RB0/RB7 pins and the CP0/CP7 pins, strictly observing the same numerical order – RB0 to CP0, RB1 to CP1 etc.

Additionally, solder a 1μF capacitor across (or in place of) the existing capacitor C7 (unless C7 is already a 1μF device, in which case leave it in position), its positive lead facing preset VR1. This reduces the oscillator rate to a very slow range.

Also for the sake of these Tutorials, put a sticky label in front of switches S3 to S6 and label them SW3, SW2, SW1, SW0, in that order from left to right.

PIC CONFIGURATION

The first thing to understand is that all PICs must be "configured" for the application they are intended to control. Such configuration includes the selection of oscillator type, and matters such as Watchdog timer and Code Protection bits use (which are discussed in Part 3). Once the configuration has been sent it is not normally necessary to change it for the same application.

In this series the setting of the configuration data into the PIC is treated as one programming operation. Sending the program itself is then another. As discussed in Part 3, it is also possible with some programmers (such as *TK3*) to "embed" the configuration code into the program itself. When the program is sent to the PIC, the configuration is then automatically set as required.

Note that occasionally (and for a variety of reasons) the configuration in the PIC can become corrupted. If you find that a program which you believe should run does not, run the configuration program (about to be described) to ensure that the PIC is correctly configured, and then re-send the program.

Sometimes corrupted configuration can prevent another program from replacing an existing one, the latter continuing to run even though the new one has been sent. In this case, use *TK3*'s Erase PIC option, and failing that run its Clear Code Protection routine (both functions described in *TK3*'s text).

Be aware that the time taken to send a program (.HEX) file to the PIC depends on its length. A delay exists because the PIC requires a minimum amount of time to store each command when received. The speed of operation has nothing to do with the speed of your computer.

Before starting the Tutorials and their exercises, configure your PIC16F84 via *TK3*. Click on the Send/Read Config Data button on *TK3*'s main screen (top centre – PIC Configuration panel). Set the configuration for RC (resistor/capacitor oscillator) with all other functions off. Send the data to the PIC. Always keep Code Protection off throughout these Tutorials.

If your PIC has been used before in some other application, you should also clear its existing program and data EEPROM contents via *TK3*'s Erase PIC button.

As the PIC is configured for RC operation, *TK3*'s RC/XTAL slide switch (S2) also needs setting for RC. Set the RC control preset VR1 for slowest oscillator rate (fully anti-clockwise).

(If you are not clear about any aspect relating to *TK3*, re-read its published text.)

NUMERICAL PREFIXES

There are four formats that can be used to express numerical values in a program. They may be expressed in decimal (e.g. 0, 4, 5), or in hexadecimal (indicated by a prefix of H', e.g. H'00', H'04' and H'05' in this case), or in binary (indicated by a prefix of B', e.g. B'00000000', B'00000100' and B'00000101'). Prefixed values must be concluded with an apostrophe suffix (') – as used in the prefix. On your keyboard the apostrophe required is that which is marked below the @ symbol (the one at top left by the numerals is not suitable).

Be aware that some PIC assembly programs (but not *TK3*) may require decimal numbers to be prefixed with D', e.g. D'10' or D'255'. It is also worth noting that some assembly programs (including *TK3*) accept the use of the dollar sign ($) to indicate hex, e.g. $F7 instead of H'F7', and for binary numbers to be prefixed by a percentage sign (%), e.g. %01010101 instead of B'01010101'.

Check with any other assembly program's documentation before using the shorter method. The D', B' and H' prefixes are those used with Microchip's own MPASM assembly programs and they do not accept % or $ prefixes. The B' and H' prefixes are used throughout these Tutorials. *TK3* accepts both prefix formats.

LISTING 1: PROGRAM TK3TUT1

```
; TK3TUT1.ASM
; minimum requirement

   ORG 0      ; Reset Vector address
   GOTO 5     ; go to PIC address
                location 5
   ORG 4      ; Interrupt Vector address
   GOTO 5     ; go to PIC address
                location 5
   ORG 5      ; Start of Program
                Memory

; (your program goes in here)

   END        ; final statement
```

You will find *TK3*'s Binary to Hex to Decimal conversion option useful if you wish to convert between the three numerical formats.

TUTORIAL 1

CONCEPTS EXAMINED

Minimum commands needed
Port default values
Instruction ORG
Instruction END
Command GOTO

The absolute bare minimum requirements for any PIC program that is to be assembled (compiled) are shown in Listing 1.

In fact, none of the statements in this listing have anything directly to do with a functioning software program. Six are aimed directly at the software assembly program, the others are comments to the human programmer, or other reader. Such comments include program title and function, and notes about what tasks particular program instructions within the list are intended to perform.

Comments must always be preceded by a semicolon (;) so that the assembler does not try to treat them as program commands. Comments may appear anywhere within the program, and in any position where they do not interfere with a program command. It is convenient, though, to place them tabulated a short distance beyond the end of program command lines.

To take Listing 1 in detail, you will see that it starts with two comments, identifying the listing and its function:

```
; TK3TUT1.ASM
; minimum requirement
```

Next come five commands which are aimed at the software assembly program (e.g. *TK3*) as well as the PIC. They need not normally concern you, repeating the commands parrot-fashion in any software you write will normally suffice (unless interrupts are involved – discussed in Part 3).

The three ORG (origin) commands and their associated address (program memory location) values tell the assembly program at which memory address within the PIC a particular set of subsequent commands is to be placed.

Position ORG 0 is known as the Reset Vector. It is to this address that the PIC jumps when it is first run or subsequently reset.

Position ORG 4 is known as the Interrupt Vector. It is to this address that PIC jumps if an interrupt occurs. The subject of interrupts will be dealt with in Tutorial 27. Ignore the concept for the moment.

Position ORG 5 is the Start of Program Memory, i.e. it is the first available position within the PIC at which the actual program itself can start.

The first two ORG statements have to be followed by a GOTO command (the first of the recommended 35 commands that the PIC understands and which you need to know!), plus an address value. The GOTO command (not surprisingly) simply tells the PIC to GO TO the address stated. The addresses can be any chosen by the program writer, but in these Tutorials are taken as GOTO 5, address 5 being the Start of Program Memory, as indicated by the ORG 5 statement.

You will notice that locations 1, 2 and 3 are not mentioned. These are reserved by the PIC and are not available for normal program use.

The bracketed statement in the listing following ORG 5 is aimed at you, the program writer: it tells you where your program is to be written. This will become evident as we progress through the example listings.

The final statement (END) is only required by some assembly programs. With *TK3* it is not essential, but you should always include it at the very end of any listing in case your programs are assembled by software that does require it.

Having included the essential first five commands and the END statement, everything else beyond ORG 5 is up to you.

INCAPABLE?

You might think that when TK3TUT1.ASM is assembled and loaded into the PIC, the PIC will be incapable of doing anything – it hasn't been told of anything to do, other than GOTO 5. Almost true, but not quite!

PICs have been told in manufacture to adopt certain "default" conditions when first switched on (those for the PIC16F84 will be shown in Part 3). One of these default conditions is that Port A and Port B are configured (set) to act as inputs. In this condition they are simply held in a high-impedance state. What is not configured at this time is the binary value which is available to be output via those pins when they are first set as outputs from within the program.

At switch-on, any number could be set randomly within the PIC's memory, of between 0 and 255 (B'00000000' to B'11111111') for Port B (eight pins), and 0 to 31 (B'00000' to B'11111') for Port A (five pins). It is often preferable, therefore, to set port output values to a known value as part of the opening program statements. This, too will become apparent as we progress.

It is also worth noting that PIC pins should never be left as "floating" inputs. If

LISTING 2 – PROGRAM TK3TUT2

```
; TK3TUT2.ASM
; setting Port B to output mode and turn
on each l.e.d.
  ORG 0     ; Reset Vector address
  GOTO 5    ; go to PIC address 5
  ORG 4     ; Interrupt Vector address
  GOTO 5    ; go to PIC address 5
  ORG 5     ; Start of Program Memory
  CLRF 6    ; set all Port B pins to logic 0
  BSF 3,5   ; instruct program that a
              Bank 1 command comes
              next
  CLRF 6    ; set all Port B pins as
              outputs
  BCF 3,5   ; instruct program that a
              Bank 0 command comes
              next
  BSF 6,0   ; set Port B pin 0 to logic 1
  BSF 6,1   ; set Port B pin 1 to logic 1
  BSF 6,2   ; set Port B pin 2 to logic 1
  BSF 6,3   ; set Port B pin 3 to logic 1
  BSF 6,4   ; set Port B pin 4 to logic 1
  BSF 6,5   ; set Port B pin 5 to logic 1
  BSF 6,6   ; set Port B pin 6 to logic 1
  BSF 6,7   ; set Port B pin 7 to logic 1
  END       ; final statement
```

any PIC pins remain unused in a PIC-controlled circuit, they should either be biased to one or other power line by individual resistors (say 10kΩ to 100kΩ), or set as outputs in a logic 0 (low) condition.

There are no exercises for Tutorial 1.

TUTORIAL 2

CONCEPTS EXAMINED

- Clock cycles
- File registers
- Bits
- Bytes
- Set
- Clear
- Command CLRF
- Command CLRW
- Command BSF
- Command BCF
- Ports and Port directions
- Register STATUS
- STATUS register bit 5
- Banks 0 and 1

CONNECTIONS NEEDED

All Port B to all l.e.d.s.
Capacitor C7 as 1μF
Preset VR1 set to maximum resistance (fully anti-clockwise)

At this point in time, a PIC without program commands is of no benefit to us! We shall now demonstrate a simple program which just turns on a series of eight l.e.d.s connected to Port B. Look at Listing 2.

As discussed in Tutorial 1, you will see comments at the start of the listing and within it, all preceded by a semicolon. You will also see the ORG and END statements, plus the GOTO 5 commands. Sandwiched between ORG 5 and END are several lines of code. The PIC considers the first program command (CLRF 6) as being at its address location 5, which is where the assembly program will place it when it loads the code into the PIC.

Ignoring the numbers following the commands, there are only three different commands in use in this program section (routine): CLRF, BSF and BCF. They simply stand for CLeaR File, Bit Set File and Bit Clear File. An allied command to CLRF is CLRW (CLeaR Working register).

Via *TK3*, assemble the program TK3TUT2.ASM, and load the resulting TK3TUT2.HEX code into the PIC. Having loaded it, the program automatically starts running. There will be a few seconds wait before you see anything happening.

From here on, whenever you are asked to load or run a program, it must first be assembled, and then its HEX code loaded into the PIC. It will automatically run when loading has finished.

At present, the oscillator which controls the PIC is only running at a very slow speed, about 1Hz or so (depending on the tolerance of the C7 and VR1 values). The internal workings of the PIC16F84 (and other PIC types) automatically divide any clock frequency by four, taking a minimum of four counts to process a single command. During each of the four intervening pulses, different aspects of the command are processed. To all intents and purposes, each command takes four clock pulses.

Each batch of four clock pulses is known as a *clock cycle*. Most commands take just one clock cycle, although some take two, partly depending on conditions resulting from their operation (see Table 1). The GOTO command takes two cycles to complete, whereas BSF, BCF, CLRF and CLRW take just one cycle.

The results of the first six commands will not produce any visible result. After a few seconds, though, each l.e.d. connected to Port B will come on in turn, in order of LD0 to LD7, with a pause between each change. When the final l.e.d. (LD7) has come on, there are no more instructions to perform, so nothing more happens (in fact, the PIC is actually working its way through each of its locations that have not been provided with code by the program).

To see the sequence again, press *TK3*'s Reset switch (S1), whereupon the program will restart from the beginning. The rate at which it occurs can be changed by adjusting preset VR1.

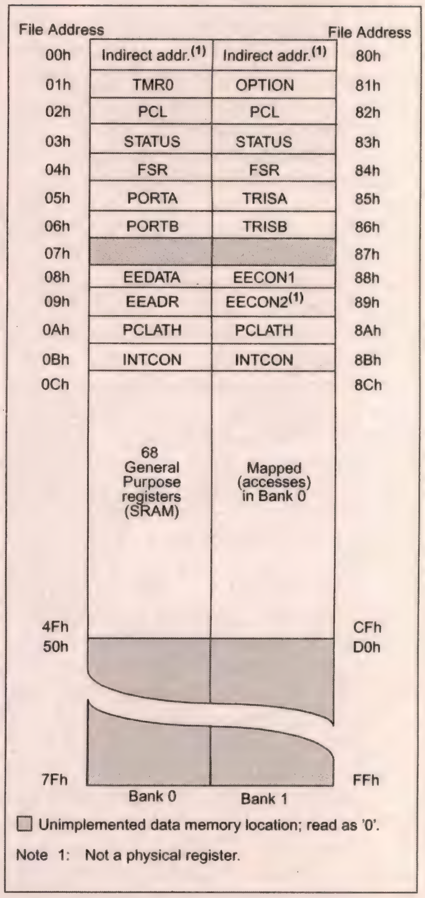
(Note that if the l.c.d. module is already connected, a very slight glow from some l.e.d.s. may just be visible, and the top line of the l.c.d. will contained darkened cells – this is normal.)

But, how does the program do what you see it has done? First, we'll tell you what File registers are and what commands CLRF, BSF and BCF do.

TABLE 3. PIC MEMORY CAPACITY

Device Type	*Program size*	*Data EEPROM*	*Registers*	*Pins*
PIC16F627	1024	128	224	18
PIC16F628	2048	128	224	18
PIC16F83	512	64	36	18
PIC16C84	1024	64	36	18
PIC16F84	1024	64	68	18
PIC16F84A	1024	64	68	18
PIC16F870	2048	64	128	40
PIC16F871	2048	64	128	40
PIC16F872	2048	64	128	28
PIC16F873	4096	128	198	28
PIC16F874	4096	128	192	40
PIC16F876	8192	256	368	28
PIC16F877	8192	256	368	40

TABLE 2. PIC16F84 REGISTER FILE MAP (courtesy Microchip)



File Address	Bank 0	Bank 1	File Address
00h	Indirect addr.(1)	Indirect addr.(1)	80h
01h	TMR0	OPTION	81h
02h	PCL	PCL	82h
03h	STATUS	STATUS	83h
04h	FSR	FSR	84h
05h	PORTA	TRISA	85h
06h	PORTB	TRISB	86h
07h	▨	▨	87h
08h	EEDATA	EECON1	88h
09h	EEADR	EECON2(1)	89h
0Ah	PCLATH	PCLATH	8Ah
0Bh	INTCON	INTCON	8Bh
0Ch 4Fh	68 General Purpose registers (SRAM)	Mapped (accesses) in Bank 0	8Ch CFh
50h 7Fh	▨	▨	D0h FFh

▨ Unimplemented data memory location; read as '0'.

Note 1: Not a physical register.

The named file addresses are known as the Special Function Registers.

FILE REGISTERS

The PIC16F84, and the other PICs mentioned earlier, have five areas of memory (see Table 3 for quantities):

1. Program Memory (EEPROM) in which are stored the commands that form the program, and where the program of TK3TUT2 is now held.
2. Data Memory (SRAM – static random access memory) in which you can *temporarily* store the results of any action that the program performs (the data is lost when the power is switched off).
3. Data Memory (EEPROM) in which you can *indefinitely* store any data that you wish to retain after power has been switched off (it will be discussed in Tutorial 25).
4. Special Function Memory (SRAM), whose attributes determine what actions the PIC takes in respect of program commands (Table 2).
5. Working Memory (SRAM – 1 byte), through which many operations have to pass during program performance (in other processors the Working Memory may be called the Accumulator).

The results (data) of any program action can be directed to be stored at any of the memory areas numbered 2 to 5 above. With items 2, 3 and 4 the destination is known as a File destination. With item 5, the Working Memory or Register, the destination is known as, not surprisingly, the Working destination.

Strictly speaking, Files should be known by their full name of File Registers. It would be tedious, though, to keep using the full name, and so the term "file" will be used throughout the Tutorials to mean File Register. (We also use the term "file" in relation to disk files – the context should make the meaning clear.)

For those of you who are familiar with programming in BASIC, files can be regarded as the equivalent of variables. There is no direct BASIC equivalent of the Working register, though in a sense it can be regarded as a special variable.

The program commands reflect the file and working destinations by the use of F and W, respectively, in the code itself. For example, in the code CLRF, the F indicates that the value in a particular file (memory data byte) is to be CLeaRed (reset to zero) and the result is to be retained in the file. On the other hand, in the code MOVLW (to be met in Tutorial 4) the W stands for Working (in this case meaning that a Literal value is to be MOVed into W). The use of both F and W in a command (e.g. MOVWF) will become evident in due course.

BITS

Having established what a file is, it is necessary (and easy) to understand the concept of a "bit". You no doubt understand it already, but, just to recap, a bit is a single part of an electronic memory which can be set to one of two states: either to logic 1 ("on" – charged to a voltage which is usually the same as the positive power rail that supplies the circuit, e.g. +5V); or to logic 0 ("off" – discharged to a zero voltage). Logic 1 and logic 0 are often referred to as high and low, respectively.

A memory i.c. can have any number of bits contained within it. A fixed number of bits is known as a "byte". There is a common misconception that a byte is only ever comprised of eight bits. Historically, this is not true, any fixed number of bits which can be operated as a single unit is called a byte. However, by current usage, a byte is usually taken to be comprised of eight bits.

The status of the bits (high or low) within a byte is expressed as a binary number reading from left to right, in order of the bit representing the highest value first (most significant bit – MSB) down to the lowest value (least significant bit – LSB). Thus decimal 128 is expressed as binary 10000000, whereas binary 1 may be expressed as 00000001 (the preceding number of zeros may not always be included – their presence being implied).

The bits of a byte are referred to by their position within a byte, with position 0 at the right, ascending as high as necessary depending on the byte length. Thus an 8-bit byte has its bits numbered as 7, 6, 5, 4, 3, 2, 1, 0. A 16-bit byte (probably referred to as a *word*) would be numbered from 15 to 0. The use of 0 (zero) as a bit number is essential to remember when programming PICs.

Incidentally, terms MSB and LSB can also be used to mean Most Significant Byte and Least Significant Byte. The appropriate meaning should be clear from the context. There are also similar terms, NSB, NMSB and NLSB, in which the N stands for Next.

TABLE 4: STATUS REGISTER (Courtesy MICROCHIP)

R/W-0	R/W-0	R/W-0	R-1	R-1	R/W-x	R/W-x	R/W-x
IRP	RP1	RP0	$\overline{\text{TO}}$	$\overline{\text{PD}}$	Z	DC	C
bit7							bit0

R = Readable bit
W = Writable bit
U = Unimplemented bit, read as '0'
- n = Value at POR reset

bit 7: **IRP**: Register Bank Select bit (used for indirect addressing)
0 = Bank 0, 1 (00h - FFh)
1 = Bank 2, 3 (100h - 1FFh)
The IRP bit is not used by the PIC16F8X. IRP should be maintained clear.

bit 6-5: **RP1:RP0**: Register Bank Select bits (used for direct addressing)
00 = Bank 0 (00h - 7Fh)
01 = Bank 1 (80h - FFh)
10 = Bank 2 (100h - 17Fh)
11 = Bank 3 (180h - 1FFh)
Each bank is 128 bytes. Only bit RP0 is used by the PIC16F8X. RP1 should be maintained clear.

bit 4: **$\overline{\text{TO}}$**: Time-out bit
1 = After power-up, `CLRWDT` instruction, or `SLEEP` instruction
0 = A WDT time-out occurred

bit 3: **$\overline{\text{PD}}$**: Power-down bit
1 = After power-up or by the `CLRWDT` instruction
0 = By execution of the `SLEEP` instruction

bit 2: **Z**: Zero bit
1 = The result of an arithmetic or logic operation is zero
0 = The result of an arithmetic or logic operation is not zero

bit 1: **DC**: Digit carry/$\overline{\text{borrow}}$ bit (for `ADDWF` and `ADDLW` instructions) (For $\overline{\text{borrow}}$ the polarity is reversed)
1 = A carry-out from the 4th low order bit of the result occurred
0 = No carry-out from the 4th low order bit of the result

bit 0: **C**: Carry/$\overline{\text{borrow}}$ bit (for `ADDWF` and `ADDLW` instructions)
1 = A carry-out from the most significant bit of the result occurred
0 = No carry-out from the most significant bit of the result occurred
Note: For $\overline{\text{borrow}}$ the polarity is reversed. A subtraction is executed by adding the two's complement of the second operand. For rotate (`RRF`, `RLF`) instructions, this bit is loaded with either the high or low order bit of the source register.

TERMS SET AND CLEAR

The concept of the terms "set" and "clear" is important to understand. In program terms, to "set" a bit means to force it high, i.e. to logic 1; the term "clear" is used to mean that a bit is forced low, i.e. to logic 0.

Note, however, that in textual terms (i.e. in articles such as this) you are likely to come across the mixed use of the word "set", in that you might be told to "set a bit low". In such cases, the implied meaning should be obvious from the context. In this example, "low" is the important word and "force" or "make" could have been used instead of "set".

COMMANDS CLRF AND CLRW

Command CLRF stands for CLeaR File and is always followed by a single number or name which indicates the file on which the action is to be performed. The command instructs the PIC that all bits within the stated file are to be cleared, i.e. it clears the whole byte (to hold a value of zero).

The allied command CLRW (CLeaR Working register) simply clears the contents of the Working register and is used on its own without a subsequent number or name. In practice, this command may be seldom used, the commands MOVLW 0 and RETLW 0 probably finding preference (these commands are discussed in Tutorials 4 and 13, respectively). Command CLRW has, in fact, been dropped from some PIC families.

There are no direct opposites of CLRF and CLRW which will set all bits high; other techniques have to be used for this action.

Using names for files instead of numbers will be dealt with in Tutorial 3.

COMMAND BSF

PICs can have any individual bit of any file byte acted upon directly. Each bit can be set high or low by a single command, and, as we shall show later, a single command will also determine the status of any individual bit.

Command BSF translates as Bit Set File and is always followed by two numbers or names separated by a comma. The first number or name is the file byte whose bit is to be acted upon. The second number or name is that representing the number of the bit within the file byte (between 7 and 0, reading from left to right).

As an example, the command BSF 3,5 in Listing 2 instructs the PIC to set (make high, force to logic 1!) bit 5 of file number 3; command BSF 6,7 means that bit 7 of file number 6 is to be set.

COMMAND BCF

Command BCF stands for Bit Clear File and is the exact opposite of BSF. As an example, the command BCF 3,5 in Listing 2 means that bit 5 of file 3 is to be cleared (set low, made/forced to logic 0!).

PORT FILE NUMBERS

In the example of Listing 2, the files whose bits have been set or cleared are those which control Port B. In terms of writing to or reading from Port A and Port B, the two ports are treated as any other file destination. However, Port A and Port B are different to other files in that they are for communication with the outside world.

There are, in fact, two file registers associated with each port that are accessible to the programmer. One is used to set the direction in which the bits are to act, i.e. as inputs or outputs (it is also known as the Data Direction Register – DDR), and the other deals with the data written to (for output to the world) or read from (input from the world). Each bit of the port direction registers can be individually set or cleared so that the same port may be used simultaneously for data input and output via different bits.

The file which controls the direction in which Port B pins respond is named in the PIC datasheets as TRISB. It is one of the named "Special Function Register" files (see Table 2) and is contained in memory byte address H'86' (we won't translate hexadecimal numbers into decimal since the latter are irrelevant in the context of file addresses).

The file which holds Port B's data, whether as input or output, is at memory byte address H'06' and, helpfully, is known in the PIC datasheet as PORTB.

A minor inconvenience exists in the PIC16F84, and the other PIC families referred to earlier, in that addresses H'80' to H'8B' can only be accessed by changing the value in another file, the STATUS file (Table 4). This file is held jointly at byte addresses H'03' and H'83'. A single bit within STATUS is used to direct the program to numbers either below H'80' (known as Bank 0 or Page 0 addresses) or above H'7F' (known as Bank 1 or Page 1 addresses); this bit is number 5. (Note that some PICs have more than two Banks.)

When STATUS bit 5 is set (logic 1), it effectively adds H'80' to the memory byte address being accessed. When the bit is clear (logic 0), addresses below H'80' are accessed. Thus, if you instruct that file 6 (H'06') is to be accessed when STATUS bit 5 is low, the file actually at address 6 will be accessed. Conversely, if you instruct that file 6 is the subject when STATUS bit 5 is high, the file at address H'86' will be accessed.

In the PIC16F84, only files numbered H'00' to H'4F' and H'80' to H'8B' are available for use by the programmer. Note that files H'07' and H'87' have no function.

It may appear from the Registers File Map in Table 2 that addresses H'8C' to H'CF' might also be available. Writing to these addresses, though, simply accesses those between H'0C' and H'4F'. (In some PICS, including the PIC16F87x and PIC16F62x families, additional memory is available at the higher Bank addresses – see *Using the PIC16F87x Additional Memory, EPE* June '02, on the CD-ROM.)

LISTING 2 COMMANDS

We can now examine each command of Listing 2 in turn and describe its purpose. When the PIC is first switched on, the STATUS file is set to a default value with its bit 5 low. All file addresses are thus treated as being below H'80'.

We have established that address 6 is that which holds the data for Port B. The first command, CLRF 6, thus clears the data which is held in Port B as a value available to be output, i.e. Port B's output register is instructed to hold a value of zero.

The purpose of the program in Listing 2 is to output data to the eight l.e.d.s on Port B, and it has already been said that the default value of Port B's direction register (at H'86') is for all bits to be set for input (all bits are high – 11111111). Consequently we must now set them all as outputs, i.e. each to logic 0, thus 00000000. To do this, first the STATUS register at address 3 must have its bit 5 set high to point to addresses of H'80' and above; hence the command BSF 3,5.

Now we configure all of Port B for output mode with the command CLRF 6. Yes, it's the same command as cleared Port B's data, but because STATUS bit 5 is high, the value of 6 (H'06') has H'80' added to it, so the address actually accessed is that at H'86'.

The commands which output data to the l.e.d.s are all concerned with Port B's data file at "real" address 6, so the addition of H'80' is no longer needed. The next command, BCF 3,5, thus clears bit 5 of the STATUS register at address 3. All remaining commands in Listing 2 can now, in turn, set high each data bit of Port B at address 6: BSF 6,0, BSF 6,1, etc., so turning on the l.e.d.s in sequence from LD0 to LD7. Simple!

LISTING 3 – PROGRAM TK3TUT3

```
; TK3TUT3.ASM
; using names to ease writing of Listing 2

STATUS    EQU 3              ; name program location 3 as STATUS
PORTB     EQU 6              ; name program location 6 as PORTB

          ORG 0              ; Reset Vector address
          GOTO 5             ; go to PIC address location 5
          ORG 4              ; Interrupt Vector address
          GOTO 5             ; go to PIC address location 5
          ORG 5              ; Start of Program Memory

          CLRF PORTB         ; clear Port B data pins
          BSF STATUS,5       ; set for Bank 1
          CLRF PORTB         ; set all Port B as output
          BCF STATUS,5       ; set for Bank 0

LOOPIT    BSF PORTB,0        ; set Port B pin 0 to logic 1
          BSF PORTB,1        ; set Port B pin 1 to logic 1
          BSF PORTB,2        ; set Port B pin 2 to logic 1
          BSF PORTB,3        ; set Port B pin 3 to logic 1
          BSF PORTB,4        ; set Port B pin 4 to logic 1
          BSF PORTB,5        ; set Port B pin 5 to logic 1
          BSF PORTB,6        ; set Port B pin 6 to logic 1
          BSF PORTB,7        ; set Port B pin 7 to logic 1
          CLRF PORTB         ; clear all PORTB pins
          GOTO LOOPIT        ; go to address LOOPIT
          END                ; final statement
```

LISTING 3A (TK3TUT3 LIST FILE)

```
List    Prog    Prog    Code     Source code
count   count   count   value
deci    deci    hex     hex

0004    0       0000             STATUS     EQU 3
0005    0       0000             PORTB      EQU 6
0006    0       0000
0007    0       0000                        ORG 0
0008    0       0000    28 05               GOTO 5
0009    1       0001                        ORG 4
0010    4       0004    28 05               GOTO 5
0011    5       0005                        ORG 5
0012    5       0005
0013    5       0005    01 86               CLRF PORTB
0014    6       0006    16 83               BSF STATUS,5
0015    7       0007    01 86               CLRF PORTB
0016    8       0008    12 83               BCF STATUS,5
0017    9       0009
0018    9       0009    14 06    LOOPIT     BSF PORTB,0
0019    10      000A    14 86               BSF PORTB,1
0020    11      000B    15 06               BSF PORTB,2
0021    12      000C    15 86               BSF PORTB,3
0022    13      000D    16 06               BSF PORTB,4
0023    14      000E    16 86               BSF PORTB,5
0024    15      000F    17 06               BSF PORTB,6
0025    16      0010    17 86               BSF PORTB,7
0026    17      0011    01 86               CLRF PORTB
0027    18      0012    28 09               GOTO LOOPIT
```

The full listing also shows binary values and comment statements.

EXERCISE 2

2.1. Using your text editor and a *copy* of TK3TUT2.ASM (renamed to any title of your choosing, but still with the .ASM extension), experiment with the eight commands relating to file 6, using different values (between 0 and 7) for the number following the comma. Do not change the number before the comma. Also experiment with changing BSF to BCF.

2.2. Rewrite the program in Listing 2 so that it performs its actions on Port A instead of Port B. The equivalent data and direction addresses for Port A are 5 (H'05') and H'85', respectively. Note that Port A only has five pins, not eight. What difference, if any, does this make to the program? You need to disconnect the wires from Port B that go to l.e.d.s LD0 to LD4, and then connect Port A pins to these l.e.d.s in correct numerical order.

You will notice that Port A pin RA4 does not appear to turn on its l.e.d. This is because the pin has an "open-collector" output which needs to be biased high, before it can be used to toggle between Logic 0 and Logic 1. An example of this is shown in Tutorial 12.

Reinstate the Port B connections to all l.e.d.s when you have finished with Exercise 2.2.

TUTORIAL 3

CONCEPTS EXAMINED

Names in place of numbers
Labels
Case sensitivity
A repetitive loop
Instruction EQU

CONNECTIONS NEEDED

All Port B to all l.e.d.s.
Capacitor C7 as 1μF
Preset VR1 set to maximum resistance (fully anti-clockwise)

In the previous section dealing with Listing 2, we were using numbers to indicate which file was being referred to. That's fine if there are only a few files whose address numbers can be easily remembered. As we progress with examining the PIC commands and example listings, though, we shall be using more and more files. If we continue to refer to them numerically, we're going to get lost! (What's file H'0C' for? Is the data supposed to go to file H'1C' or file H'1E'?)

Human memories with numbers are notoriously bad! But we are (usually) much better with names. This fact was long ago recognised by program writers and many types of software allow the use of names in place of numbers. Let's examine how names can be applied to the numbered files in Listing 2. Have a look at Listing 3.

Any number written into a listing can be represented by a name. It can be any name you like as long as you think you'll know in time to come what is meant by that name (but some assembly programs impose a limit on name lengths, although *TK3* does not). There are also some names which it is better to allocate according to their function, especially those functions that already have names provided in the PIC datasheets, such names as STATUS and PORTB, for example.

With some programmers (but not *TK3*), the names are "case-sensitive". In other words, once you have equated a name with a number, further use of the name must be in exactly the same style as the original with regard to the use of upper and lower case letters. For example, names PORTB and portb should not be used interchangeably. It is recommended, though, that you do not use different upper and lower case styles of the same word to mean different things.

However, the commands themselves (as opposed to the names) may be in upper or lower case without (usually) causing problems. For example, for clarity on these published pages, the commands are shown in upper case. In the actual full ASM listings, though, the same commands are principally in lower case – the *TK3* assembly program recognises both styles.

EQUATING NAMES

In Listing 3, three names have appeared: the aforementioned "aliases" STATUS and PORTB, plus LOOPIT. We'll keep LOOPIT a mystery for the moment (but we're sure you know what it's for). All "alias" name allocations must appear at the head of the program listing, in the initialisation block.

Then the format for allocating a name to a number is to state the name at the left of a program line followed by at least one space, although you may have more than one space if you prefer, to keep things looking neat and tabulated. Most assembly programs allow the use of the Tab key to keep columns tabulated, which makes typing easier than keying-in lots of spaces.

Now the statement EQU is made, followed by a space and the number you wish to name. In the case of the first line, STATUS is the name to be given to the numeral 3 (which, you will remember, is the file address number for the STATUS register). Hence, the statement:

```
STATUS EQU 3
```

This simply tells the assembler program that when it assembles the listing into code, each time it comes across the name STATUS, it is to replace it in the code by the value of decimal 3.

The second line similarly allocates the name PORTB to file address 6:

```
PORTB EQU 6
```

Compare Listing 2 and Listing 3; you will see how the program has been rewritten using the names in place of file numbers.

It is permissible to use other numerical formats, such as binary and hexadecimal, in EQU number defining.

LIST (.LST) FILES

When ASM source code files are assembled, a List file (.LST) is generated as well as the HEX file. A list file allows examination of the original ASM source code and the actual values that the assembly program generates in respect of that code.

Some assemblers generate separate list files for each source code file, using the same basic file name, but giving an extension of .LST. *TK3*, though, uses a common file name that is used for all list files (TK3ASM.LST).

Click on the LIST button in *TK3*'s Assembly zone to open the LST file created when TK3TUT2.ASM was assembled, and print it to paper. Then assemble TK3TUT3.ASM and print out its LST file. A section of it is repeated in Listing 3A.

Examining both printouts you will see that the Program Count and Code Value hex numbers are the same in both listings, except for the last two (new) commands of TK3TUT3.

The LST files also include the programmer's notes at the right. They have been omitted from Listing 3A to conserve space. The lefthand column (List count deci) holds the text line numbers as encountered in the text file listing (ASM) and are in decimal. They serve no programming purpose and are simply there for your information.

The second and third columns show the actual address location number (in decimal and hex respectively) within the PIC at which the command will be placed.

Command ORG 0 causes its associated GOTO 5 statement to be coded at location 0, similarly with ORG 4 and its GOTO 5 statement for location 4.

Note how columns four and five, which hold the 2-byte hex code and the equivalent binary (14-bit) value (not shown in Listing 3A), are only used if a command is encountered. For example, command GOTO 5 generates the code 28 05 (H'2805'), and command CLRF PORTB generates the code 01 86 (H'0186').

The .HEX file holds the code values in hexadecimal. The 14-bit binary value is that which is converted from the hex value and sent to the PIC as serial data.

TK3TUT3 FOREVER!

Now load the code for TK3TUT3.HEX into your PIC. It will be seen to start off in the same way as TK3TUT2. Now, though, when it gets to the end of the code, the l.e.d.s will all go out and the sequence will repeat, indefinitely! You will find that a fully-clockwise setting of VR1 becomes preferable, to increase the display rate.

The program difference now is that there are two extra commands and when command BSF PORTB,7 has been performed, Port B is cleared and the program follows the command GOTO LOOPIT. LOOPIT is the name given to the address at which the command BSF PORTB,0 has been placed. During assembly that address number has been noted and each time the assembler encounters a command reference to the address named LOOPIT, it substitutes the number for that address. There is just one reference in this program, but other programs may have many such references.

Names, when given to program listing addresses, as with LOOPIT here, are commonly known as "labels". Referring to the .LST listing for TK3TUT3, the numbered line 0018 reads:

```
0018 9 0009 14 06 LOOPIT BSF PORTB,0
```

Note the value 9 in column 3. Now look at line 0027, which reads:

```
0027 18 0012 28 09 GOTO LOOPIT
```

Now note the 09 in column 5. The two values are equal and intentional. The address for which LOOPIT is the reference name (label) is at location 9; the code 28 09 contains the instruction to GOTO (jump to), plus the address number to which it is to jump.

In other instances, the addresses may be much greater than the one illustrated here, and the two values will differ accordingly, but the point is that the name LOOPIT is replaced by an address value during assembly and as such is treated by the Assembler in the same way as were STATUS and PORTB.

This fact has another important significance: when a number has a name allocated to it, each time the assembly program encounters that name it substitutes the appropriate number. Names can be given to addresses (as just illustrated), to register files (as with PORTB), and even bit numbers (Z to represent the Zero flag bit of the STATUS register, as shown later).

We shall also show examples of names being used as pointers to addresses when the address required may depend on a particular value established as a result of calculation, i.e. in the case of Indirect Addressing, which will be examined in Tutorial 16.

It is worth noting that *TK3* allows labels to be suffixed by a colon (:), e.g. LOOP:, which makes labelled routines easier to find using a text editor's Search or Find facility in a long program that has many calls to a particular label. Microchip's assembly programs do not permit this.

TABLE 5. SPECIAL FUNCTION REGISTERS

Register	*Address*	*Bank*	*Tutorial*
EEADR	09	0	25
EECOCN1	08	1	25
EECON2	09	1	25
EEDATA	08	0	25
FSR	04	0·1	16
INDF	00	0·1	16
INTCON	0B	0·1	18
OPTION	01	1	18
PCL	02	0·1	4
PCLATH	0A	0·1	14
PORTA	05	0	4
PORTB	06	0	4
STATUS	03	0·1	2
TMR0	01	0	18
TRISA	05	1	4
TRISB	06	1	4

LISTING 4 – PROGRAM TK3TUT4

```
; TK3TUT4.ASM
; using aliases, bit names and conditional loops

#DEFINE BANK0 BCF STATUS,5
#DEFINE BANK1 BSF STATUS,5

STATUS    EQU 3            ; STATUS register
TRISA     EQU 5            ; Port A direction register
PORTA     EQU 5            ; Port A data register
TRISB     EQU 6            ; Port B direction register
PORTB     EQU 6            ; Port B data register

W         EQU 0            ; Working register flag
F         EQU 1            ; File register flag
C         EQU 0            ; Carry flag

          ORG 0            ; Reset Vector address
          GOTO 5           ; go to PIC address location 5
          ORG 4            ; Interrupt Vector address
          GOTO 5           ; go to PIC address location 5
          ORG 5            ; Start of Program Memory

          CLRF PORTA       ; clear Port A data register
          CLRF PORTB       ; clear Port B data register
          BANK1            ; set for BANK1
          CLRF TRISA       ; set all Port A as output (clear direction reg)
          CLRF TRISB       ; set all Port B as output (clear direction reg)
          BANK0            ; set for BANK0

LOOP1     MOVLW 1          ; load value of 1 into Working register
          MOVWF PORTB      ; load this value as data into Port B
          BCF STATUS,C     ; clear Carry flag

LOOP2     RLF PORTB,F      ; rotate value of PORTB left by 1 logical place
          BTFSS STATUS,C   ; check if the Carry flag (bit 0) of the STATUS
          GOTO LOOP2       ; command is actioned only if PORTB is not yet 0
                           ; the program jumping back to address LOOP2
          GOTO LOOP1       ; command is actioned only when PORTB now = 0
          END
```

EXERCISE 3

3.1. Do the same sort of program modifications that you did with Exercise 2, examining the results achieved. Also try changing the position of the LOOPIT address in the lefthand column, putting it alongside BSF PORTB,2 for example.

3.2. The command GOTO LOOPIT can also be put elsewhere; try putting it between BSF PORTB,4 and BSF PORTB,5 and see what the result is.

There is an easy way of moving it in this instance without actually doing so: put a semicolon (;) in front of the three lines following BSF PORTB,4. The Assembler will then treat these lines as comments and ignore them. The use of a semicolon is a handy way to temporarily omit commands when debugging programs (locating errors).

3.3. What happens if a semicolon is put in front of any of the three CLRF PORTB commands?

TUTORIAL 4

CONCEPTS EXAMINED

Naming numbers
Bit naming
Bit codes C, F, W
Bit testing
Carry flag
Conditional loop
Instructions BANK0 and BANK1
Instruction #DEFINE
Pin protection
Command MOVLW
Command MOVWF
Command RLF
Command RRF
Command BTFSS
Command BTFSC
Command PCL
Program counter
Register PORTA
Register PORTB
Register TRISA
Register TRISB
Register PCL
STATUS register bit 0

CONNECTIONS NEEDED

All Port B to all l.e.d.s.
Capacitor C7 as 1μF
Preset VR1 set to minimum resistance (fully clockwise)

INSTRUCTIONS #DEFINE AND BANK

One concept that you are likely to see in PIC software is that of defining a frequently used command format as a single name. Each time the Assembler encounters that name during assembly, the defined command will be substituted in the coding. Two such definitions appear in Listing 4:

#DEFINE BANK0 BCF STATUS,5
#DEFINE BANK1 BSF STATUS,5

The command BANK0 is then used each time the programmer would otherwise key in BCF STATUS,5. Likewise with BANK1. It is not only shorter, but conveys another concept more clearly than would direct manipulation of STATUS bit 5, that of Banks (or Pages), which were referred to in passing earlier. We have shown that STATUS bit 5 switches between addresses H'00' to H'4F' and H'80' to H'8B'. In fact, the latter extends to H'CF', but addresses greater than H'8B' are not available to the programmer. Writing to them simply wraps them back to an address H'80' bytes earlier.

We have so far equated two file names and address values, STATUS as 5 and PORTB as 6. You will have seen that they actually represent three functions, the STATUS function which is accessed jointly at locations H'03' and H'83', and two functions for PORTB accessed at H'06' and H'86'. With the PIC16F84 all Special File Registers are held between H'00' to H'0B' and H'80' to H'8B' (see Tables 2 and 5).

It makes for an easy shorthand way of defining which group is which by giving them names. As Microchip refer to these groups as being in Bank 0 and Bank 1, these are convenient name types to use. This, then, is why the terms BANK0 and BANK1 have been defined as above: it is simply an easy to remember convenience. BANK0 holds the H'00' to H'0B' group, and BANK1 holds the H'80' to H'8B' group. Note that you may sometimes come across the term Page instead of Bank to represent the same concept.

DOUBLE EQUATING

In Listing 4, following the three definitions we see STATUS, PORTA and PORTB being nominated (EQUated) as in Listing 3, representing register addresses 3, 5 and 6 respectively. The names TRISA and TRISB have crept in, though, and they also relate to register addresses 5 and 6 respectively. Why two names for the same number? It is done for the convenient reason that we know address 6, for example, relates to registers which appear in both BANK0 and BANK1, but which have different functions, Port B's data and direction registers, respectively.

It saves confusion, therefore, to have a different name for each, even though their address numerals are the same. The name TRISB is given to Port B's direction register since this is the name given to that function in PIC datasheets. The name PORTB now simply refers to Port B's data register. Exactly the same convention is applied to Port A, using PORTA and TRISA as the names in relation to location 5.

Incidentally, as mentioned earlier, there is a command TRIS available as part of the command set of some early PICs. Microchip recommend that it should not be used since it has been deleted from the PIC16F84 and later chips. The same applies to the command OPTION. Neither of these commands will be discussed here. You will see the use of TRISA, TRISB and OPTION_REG in this *Tutorial*, but the terms are used as Register file names, not as commands.

Where Special Function registers have had their functions equated to a name that is similar, henceforth the new name will be used. For example, Port B will be referred to as PORTB, Port A as PORTA and Status as STATUS. Additionally, in order to avoid repetition of comments made in earlier listings, from now on listing comments will not always be shown here for situations that have previously been discussed. The full listings, however, show comments where appropriate.

PIN PROTECTION

It was said earlier that unused PIC pins should never be left as "floating" inputs. The easiest way to ensure that they are not is to set them as outputs and to set their output value to 0. This is why PORTA and TRISA conditions have been specified, even though PORTA is not actually used in program TK3TUT4.

BIT NAMES

All the numerals to which names have been allocated so far have been related to file (register) byte addresses. It is equally possible to allocate names to particular bits in a file byte. This is especially useful when individual bits of particular files perform specific functions. Three examples are shown in Listing 4:

```
C      EQU 0
W      EQU 0
F      EQU 1
```

BIT NAMES F AND W

We have already said that data can be routed either to files or retained in the Working register. A single bit code, either 0 or 1, determines which destination. This bit value statement is required following the comma used with some commands.

For example, take the two similar commands RLF PORTB,0 and RLF PORTB,1, the command RLF (which is discussed in a moment) tells the PIC that the value within the file then stated (in this case the file is PORTB) is to be rotated left (multiplied by two). The result of this rotation can either be put back into PORTB, using the 1 suffix, or held in the Working register for further use, using the 0 suffix. If the Working register is chosen, the value in PORTB remains as it was.

Again for easy human understanding, it is more convenient to give a name to the different conditions than having to remember numbers. So the file destination 1 is called F for File, and the Working destination 0 is called W for Working. All very logical and clear! The two example commands thus become RLF PORTB,W and RLF PORTB,F.

CARRY FLAG C

One bit of STATUS (see Table 4), bit 0, is the bit which indicates whether a Carry or a Borrow has occurred during some commands. (It is, incidentally, common to refer to such bits as being "flags": the flag is then said to be set or cleared by any action which affects it.) The Carry flag is frequently required to be read in most programs and it is convenient to also give it a name, in this case C, hence the setting-up statement:

```
C      EQU 0
```

The bit can be manipulated or tested by commands such as BCF STATUS,C or BTFSS STATUS,C (discussion of BTFSS comes in a jiffy or two).

Before going any further with the contents of Listing 4, load its code into the PIC (TK3TUT4.HEX). What you will see is that the eight individual l.e.d.s on PORTB are being turned on at the same time the preceding one is turned off. The movement will appear to be going from right to left, from bit 0 to bit 7 (LD0 to LD7), and restarting at bit 0.

There are several ways of doing this (and many reasons why you should need to). Two programming techniques are discussed here, the one in Listing 4, and then a much shorter one later in Listing 5. The one in Listing 4 demonstrates the use of the commands MOVLW, MOVWF, RLF, BTFSS, and how two loops can be "nested" and made dependent upon each other.

COMMANDS RLF AND RRF

Many of you will be familiar with the electronic concept of shift register chips. Data can be loaded into the register either serially (bit entry) or in parallel (byte entry). The data can be shifted to the "left" or "right" in the chip, in response to a clock signal. The shifted data can then be made available either serially as bits, or in parallel as a byte. When data is shifted left and read as a byte (parallel output), each shift has the effect of multiplying the data by two. Shifting to the right divides it by two.

Take the 8-bit binary code 00000100 (decimal 4), for example. If this is shifted left by one place, the result is 00001000 (decimal 8). If the code had been shifted right by one place, the result would be 00000010 (decimal 2).

Most files within a PIC are capable of having their data shifted (rotated) to the left or to the right (although doing so on the Special Function Registers may sometimes produce unpredictable results). The two commands are RLF and RRF (Rotate Left File and Rotate Right File).

Both commands have to be followed by the file which is to have its data rotated, then a comma and then the destination, either F or W. For example: RLF PORTB,F or RLF PORTB,W. If the W destination is chosen, the original contents of the file remain intact (the result going into W); they are only changed if the F suffix is used, which causes the result to be placed back into the file, over-writing its previous value.

There are two problems associated with rotating a file's contents left or right. For the first, consider the situation when a file (for the sake of example, call it PORTB) contains a value such as 11010111 (decimal 215); there are many numbers that could illustrate the point about to be made. Suppose the rotate left command RLF PORTB,F is given, all bits are rotated left by one place. The value retained in PORTB becomes 10101110 (decimal 174) which is definitely not 2 × 215; the original lefthand bit has vanished from this 8-bit byte – a 9-bit byte would be needed to show the correct answer.

RIGHT AND CARRY

Alternatively, suppose the rotate right command RRF PORTB,F is given, all bits are rotated right by one place. The value retained in PORTB becomes 01101011 (decimal 107), which is definitely not 215/2; the original right-hand bit has vanished from this 8-bit byte.

In some cases, of course, the intention of rotating left or right may have nothing to do with multiplying a value by 2. It may be that we simply want to change the position of the bits for another purpose, such as changing the commands sent to the outside world to turn equipment on or off. In this case, the arithmetic accuracy of the rotate result would be immaterial.

The other problem (although it can be used beneficially) is that bits rotated out from either end of the byte are rotated into the Carry bit of STATUS. Simultaneously, the previous value held in the Carry bit is rotated into the byte at the other end.

Suppose that the Carry bit is initially zero. In the first RLF example above, the original value of 11010111 would be rotated left and the result would be correct as shown (10101110) because the 0 has come in to the right from the Carry bit. However, the last lefthand bit of the original value (which is a 1) would now be in the Carry bit.

Suppose then that another rotate left is made. The bits within PORTB would be rotated left but, at the same time, the Carry bit from the previous rotation would now be rotated into PORTB from the right. The value held in PORTB thus becomes 01011101 (decimal 93), and again the Carry bit now holds the 1 from PORTB bit 7. Therefore, the next rotation will result in an answer of 10111011 (decimal 187).

To avoid a set Carry bit (*which retains the status last acquired anywhere in the program*) being rotated automatically into a file byte from the other end, the Carry bit can be cleared by the command BCF

STATUS,C prior to each rotate command, unless, of course you want a set Carry bit rotated into a byte.

Referring again to the display you see on the l.e.d.s at the moment, controlled by TK3TUT4, the Carry bit clearing technique is being used immediately prior to the RLF command. We shall show what happens if the Carry is not cleared when TK3TUT5 is viewed later.

COMMAND MOVLW

In Listing 4 is the command MOVLW 1. The MOVLW command (MOVe Literal value into W) is the command which allows literal values (numbers) contained within the program itself to be moved (copied) into the Working register for further manipulation. The range of values is from 0 to 255, i.e. an 8-bit byte. Command MOVLW 1 instructs that the value of 1 is to be moved into W. Literal values may be expressed in decimal, hexadecimal or binary, e.g.:

```
MOVLW 73 (decimal)
MOVLW H'49' (hexadecimal)
MOVLW B'01001001' (binary)
```

Literals may also be the address values of other files whose names have been specified at the head of the program, or they may be the values assigned to be represented by other words or letters. The following are all legal commands:

```
MOVLW STATUS
MOVLW PORTB
MOVLW W
MOVLW LOOP1
```

Respectively, the commands would move into W the address value of STATUS (which we have specified as 3), the address value of PORTB (6), the value assigned to be represented by W (0), the address within the program at which the command line prefaced by label LOOP1 resides (a value known only to the program – unless you examine the LST file).

An important point about any of the Move commands, such as MOVLW, MOVWF and MOVF is that the original value (source value) itself remains where it is and is unchanged. The value is simply "copied" into the destination specified. Having moved a literal value into W it can then be immediately moved into a specified file destination, or it can be used as part of a further manipulation.

COMMAND MOVWF

Following the MOVLW 1 command in Listing 4 is the command MOVWF PORTB. Command MOVWF (MOVe W into File) simply copies the contents of the W register into the file specified, in this case PORTB. Apart from the destination statement, no commas or other statements are needed (or allowed) with this command. The MOVWF command is the only way in which full bytes of data can be copied from W into other destinations. As used in Listing 4, it is the value of 1 which is copied.

COMMAND BTFSS

Another command we are introducing in Listing 4 is BTFSS, Bit Test File Skip if Set. What BTFSS does is to examine the status of the file bit specified in the remainder of the command (bit C of STATUS in this case: BTFSS STATUS,C).

The word Set now becomes the important one. The PIC is being asked to test if the bit specified is Set (i.e. is it logic 1?). There can only be one of two answers, either "yes" or "no". In programming (and digital electronics too) if the answer is "yes", then the answer is said to be "true". If the answer is "no", then the answer is said to be "false" (not true).

Now we come to a situation which some find difficult to grasp until they understand "what" happens when the validity of the question has been established. It's simple, though, once the facts are known!

The convention is that if a situation is "true" then it can be represented by logic 1, Conversely, if the situation is "false" it can be represented by logic 0. Logic 1 and logic 0 are, of course, the two states in which a binary bit can be. Hold this idea in your mind for a moment and consider the next fact.

We have shown that programs are stored as instructions in consecutive memory bytes. It has also been shown that these bytes are numbered from zero upwards (Listing 3A). Microcontrollers such as PICs keep track of which program byte number is currently being processed, and there is a counter which holds this information – the Program Counter (PCL, as it is named for the PIC, Program Counter Low). Unless told otherwise, when one instruction has been performed, the program counter is automatically incremented (a value of 1 added to it) and the next consecutive command is performed.

CHANGE OF ADDRESS

The program address number held by the PCL can be changed, either when the instruction is one such as GOTO or CALL, or by the user telling it to add another literal value to itself. The next instruction performed is that at the address pointed to by the new value. It will be seen, then, that if the value of 0 is added to the PCL, the next instruction is simply the next one on. If, however, the value of 1 is added to the PCL, then the next consecutive instruction is bypassed (skipped) and the one beyond it is performed instead.

For example, if the program counter is at 52, then normally it will automatically add one to itself and the next instruction will be that at 53, and the one after that will be at 54, etc. If, somehow, we intervene and add 1 to the counter while it's still 52, the counter will become 53 but will still add its own value of 1 to itself, making 54. The program will thus jump straight from 52 to 54, omitting the instruction at 53. Should the value of 0 be added, then, of course, the program will go straight from 52 to 53.

Coming back to BTFSS, we know that the answer will be either 0 or 1. When the PIC performs the BTFSS command, the answer is automatically added to the PCL. Therefore, still assuming a PCL starting value of 52, if the answer is true (1), the PCL has 1 added to it and so the next instruction performed is that at 54, as above. If the answer is false (0), then zero is added to PCL and so the instruction at 53 is performed, again as above.

Look again at Listing 4 and the command BTFSS STATUS,C, i.e. we are checking if bit C of STATUS is set (true). If if is true that the bit is set, then the 1 of the truth answer is added to PCL and so the command GOTO LOOP2 is bypassed and that which says GOTO LOOP1 is performed. If STATUS bit C is not set (false) then the program simply takes GOTO LOOP2 as the next command because the 0 of the false answer is added to PCL. OK so far?

COMMAND BTFSC

While this concept in still in your minds, let's look at the command which is the opposite of BTFSS, namely BTFSC (Bit Test File Skip if Clear). What this command does is to check if it is true that the bit being tested is clear (0). If it is true that the bit is clear, then the answer is 1. If it is false that the bit is clear (that the bit is not 0, but 1), then the answer is 0.

Let's see what happens in Listing 4 if we replace BTFSS by BTFSC. The command BTFSC STATUS,C tests the C bit to find out if it is true that it is clear. If it is true, 1 is added to PCL and command GOTO LOOP1 is performed. If it is false that bit C is clear, then 0 is added to PCL and so GOTO LOOP2 is performed.

We have, perhaps, somewhat laboured this explanation, but the concept of bit testing and the resulting action is one which causes some people problems, especially when testing for a bit being clear.

Why, they ask, is it that the answer is 1 if the tested bit is zero? Why does 1 equal 0? It doesn't, what you are looking for is the truthful answer to the question posed. Think about the question, think about the answer to it.

It is an important concept to grasp, and there are other situations where it occurs: when testing the Digit Carry and Zero flags of the STATUS register (bits 1 and 2, respectively). We shall encounter those situations in Tutorials 5 and 7.

LISTING 4 AGAIN

What you see the program of Listing 4 doing is the simple action of repeatedly "moving" an l.e.d. from right to left. There are only seven commands involved, yet, as witnessed by the length of discussion so far, there are several important commands and their concepts to be fully understood.

Let's relate those commands in simple terms to what is happening in the program.

First, at label LOOP1 the value of 1 is moved into W, this is then moved into PORTB, setting its bit 0 to 1 and clearing bits 1 to 7. As a result, the first l.e.d. at the right is turned on (LD0) and the others (LD1 to LD7) are turned off. In binary, PORTB's value is now 00000001.

Next, the Carry bit of STATUS is cleared to prevent it from interfering with the results of the rotate-left command that follows at label LOOP2 (as discussed earlier). You will see that this command is RLF PORTB,F. The F suffix means that the result of the rotation is retained in PORTB, and the contents of PORTB will have shifted so that the second l.e.d. (LD1) has come on because the 1 previously set by the MOVWF command has shifted from PORTB's bit 0 to its bit 1. Since the Carry bit was previously cleared, 0 is moved into PORTB bit 0, turning off l.e.d. LD0. The binary value has become 00000010.

Now the value of the Carry bit in STATUS is checked to see if a 1 has been shifted out from PORTB bit 7. In fact, it cannot have occurred yet since it takes eight shifts to bring the 1 from the right and into Carry. However, the PIC is not aware of that fact, so the Carry bit has to be checked following each shift left.

If the Carry bit is not yet set, the command GOTO LOOP2 is performed, the program jumps back to that stated position and the RLF command is again actioned. As a result the third l.e.d. (LD2) will come on and the second l.e.d. (LD1) will go out, binary 00000100.

Eventually, after eight shifts, the 1 will have shifted through all eight bits of PORTB and into the Carry bit. At this point, there will be no bits set in PORTB, and so no l.e.d.s will be on. Now, on the test for the Carry bit being set, the answer will be true, command GOTO LOOP2 will be bypassed and the command GOTO LOOP1 will be performed, the program jumping to that label. The whole sequence then recommences by a 1 again being loaded into PORTB bit 0. As written, the program will repeat until the PIC is switched off or the Reset switch is used.

EXERCISE 4

4.1. What do you think will be the l.e.d. display sequence if another value is loaded into PORTB via the MOVLW command? Try any multiple of 2; then try any value that has more than one bit set, using the binary format, e.g. B'01001100'.

4.2. Also see what happens if the command RRF PORTB,F is used instead of RLF PORTB,F. What do you think will happen if you replace PORTB,F by PORTB,W? Then see what happens if BTFSC is used instead of BTFSS? (It is a common mistake to use the wrong command in this sort of situation.) Now swap the two commands GOTO LOOP2 and GOTO LOOP1.

4.3. Just out of interest, also try deleting the command BCF STATUS,C (just put a semicolon in front of it).

A SIMPLER ROTATION

Load TK3TUT5.HEX – it will be seen to be shifting the l.e.d. display to the left, as occurred when TK3TUT4.ASM was first run as TK3TUT4.HEX (before you started changing it – although, hopefully, you saved each variant under a different name).

You should notice that TK3TUT5 is running a bit faster than TK3TUT4 did. This is because there are now fewer commands to process for the same result. Simplicity of code usually makes for faster processing speeds (or, rather, the fewer commands that need to be processed to perform a particular function, will result in a faster processing speed). Look at Listing 5 and you will see how few commands there are in the loop, just two. Let's examine the program flow.

LISTING 5 – PROGRAM TK3TUT5

```
; TK3TUT5.ASM
; Showing how Carry bit rotates into register
#DEFINE BANK0 BCF STATUS,5
#DEFINE BANK1 BSF STATUS,5

STATUS          EQU 3
TRISA           EQU 5
PORTA           EQU 5
TRISB           EQU 6
PORTB           DQU 6
W               EQU 0
F               EQU 1
C               EQU 0
                (ORG0 TO BANK0 as
                previously)
                BSF STATUS,C
LOOP            RLF PORTB,F
                GOTO LOOP
                END
```

In the full listing everything up to the statement BANK0 is the same as in TK3TUT4. Then advantage is taken of the fact that a set Carry bit will be shifted into a file when it is rotated left or right; the command BSF STATUS,C is given before the loop, so setting the Carry bit. Now when PORTB is rotated left with the command RLF PORTB,F, the Carry bit comes straight into PORTB bit 0, turning on l.e.d. LD0. Simultaneously, the Carry bit is cleared (remember why?).

The next command is GOTO LOOP, which the program does, again to rotate PORTB, causing LD1 to come on and LD0 to go out. For eight rotations left, the Carry bit remains clear, then on the ninth rotation the original 1 that has traversed PORTB will drop into the Carry bit, to be rotated back into PORTB on the next rotation. And so it goes on, indefinitely.

There are numerous situations in which rotation occurs and when the setting of the Carry bit is desirable. In this way, several files can be coupled as a very long shift register, e.g.:

```
BSF STATUS,C
RLF FILE1,F
RLF FILE2,F
etc. to
RLF FILE15,F
```

EXERCISE 4 CONTINUED

4.4. What happens if you add another RLF PORTB,F after the first? And if you add a third RLF PORTB,F?

4.5. What happens if you substitute a W for the F in one of the statements?

4.6. What happens if you amend the program to work with PORTA (changing the l.e.d. connections again) – why does the sequence not repeat with the Carry bit rotating back into PORTA? (What is different about PORTA and PORTB?)

TUTORIAL 5

CONCEPTS EXAMINED

STATUS bit 2
Zero flag
Bit code Z
Command MOVF

CONNECTIONS NEEDED

All Port B to all l.e.d.s.
Capacitor C7 as 1μF
Preset VR1 set to minimum resistance (fully clockwise)

It is appropriate at this moment to introduce a command allied to the Carry bit tests, testing the Zero flag bit of the STATUS register. This is bit 2 and in the heading of program TK3TUT6, shown in Listing 6, the letter Z has been equated to it:

```
Z       EQU 2
```

LISTING 6 – PROGRAM TK3TUT6

```
; TK3TUT6.ASM
; Using RRF and Z, Status bit 2
; Zero flag use, Command MOVF
        (Definitions, through to
        BANK0 as previously)
LOOP1   MOVLW B'10000000'
        MOVWF PORTB
        BCF STATUS,C
LOOP2   RRF PORTB,F
        MOVF PORTB,F
        BTFSS STATUS,Z
        GOTO LOOP2
        GOTO LOOP1
        END
```

The two opposite commands for zero testing are BTFSS STATUS,Z and BTFSC STATUS,Z, identical to the Carry checking commands except for the change of final letter.

We also take the opportunity to formally demonstrate command RRF (Rotate Right File). It was described in Tutorial 4, but not shown. You probably used it, though, when experimenting with Exercise 4. Thirdly, the command MOVF is introduced and demonstrated. Run TK3TUT6.HEX and refer to Listing 6.

The l.e.d. display controlled under TK3TUT6 should be seen to be rotating right, but otherwise the display repetition should be as seen in TK3TUT4 and TK3TUT5. The program opens up with the necessary initialisation commands. The command at LOOP1 is then seen to be MOVLW B'10000000' instead of the previous MOVLW 1. The set bit (1) is now at the left of the byte, instead of at the right (00000001).

This is moved into PORTB and the Carry bit is cleared, both commands as in Listing 4. At LOOP2, command RRF PORTB,F now replaces RLF PORTB,F, instructing the program to rotate to the right, the 1 moving progressively from bit 7 to bit 0 and then into the Carry bit. Next comes MOVF PORTB,F. Let's examine it.

COMMAND MOVF

Whereas MOVLW means moving a literal value into W, MOVF means MOVe File value. The file (PORTB in this case) is named following the command, but the command itself does not say where the value is to be moved (unlike MOVLW, where W as the destination is included in the command). The destination is stated by adding a comma after the file name and then adding either W or F, e.g.:

```
MOVF PORTB,W or
MOVF PORTB,F
```

Normally, the command would be used with W, so that the contents of the file are brought into W for presumed further use. At first, then, the concept of using F as the destination seems strange. Why move the file value back into the file without the value having undergone some sort of manipulation?

The reason is that many commands automatically affect various flags in the STATUS register (see Tables 1 and 4), setting or clearing them as appropriate. We have already seen the Carry flag being affected by RLF and RRF, but the Zero flag is not affected by these two commands, so a different technique has to be used to check for zero.

When command MOVF is performed, irrespective of the W or F destination, the Zero flag is affected. It is set if the file value is zero, cleared if the file value is greater than zero. So, if we wish to know whether or not the file value is zero, we can use the MOVF command to affect the zero flag, and do so without changing the file value. It is also significant that the contents of the W register are not affected when using the F destination and can therefore be used elsewhere if needed following the result of the zero check.

That is what is happening in Listing 6, moving F back into F to affect the Z flag, which is about to be tested in the next command, BTFSS STATUS,Z. What is being looked for is PORTB's value becoming zero after the 1 has exited from the right of the file (from bit 0).

The logic of BTFSS STATUS,Z is the same as that for the Carry flag. We are looking for the truthful answer to a question, in this case is it true (1) that the Zero flag is set (1)? The answer will only be true if the file value is zero (0) – another of those concepts which some people may find difficult to comprehend, a 1 being used to mean the presence of 0.

If the file value is greater than zero, i.e. does not equal 0, then the answer is false (0) and so the Zero flag is cleared (0). As with Carry testing, the result of the Zero test (1 or 0) is added to the program counter (PCL) and, depending on the result, either GOTO LOOP2 (Z = 0) or GOTO LOOP1 (Z = 1) is the command actioned. Consequently, LOOP2 commands will be cycled through eight times before a jump is again made to LOOP1.

EXERCISE 5

5.1. Prove that the Zero flag is affected by the command MOVF PORTB,W as well as MOVF PORTB,F (the proof is that the rotation is the same as before).

5.2. What happens if the B'10000000' of command MOVLW B'10000000' is replaced by another number? Experiment with different values.

TUTORIAL 6

CONCEPTS EXAMINED

Command INCF
Command DECF
Command INCFSZ
Command DECFSZ
Counting upwards (incrementing)
Counting downwards (decrementing)
Use of a file as a counter

CONNECTIONS NEEDED

All Port B to all l.e.d.s.
Capacitor C7 as 1μF
Preset VR1 set to minimum resistance (fully clockwise)

Load TK3TUT7.HEX and refer to Listing 7.

This first thing to notice in Listing 7 is that a new name, COUNT, has been added. It has been equated in the full listing as:

```
COUNT EQU H'20'
```

LISTING 7 – PROGRAM TK3TUT7

```
BEGIN       CLRF COUNT
LOOP1       MOVF COUNT,W
            MOVWF PORTB
            INCFSZ COUNT,F
            GOTO LOOP1
LOOP2       MOVF COUNT,W
            MOVWF PORTB
            DECFSZ COUNT,F
            GOTO LOOP2
            GOTO LOOP1
```

This represents the first example of the use of an "ordinary" file (as opposed to a Special Register File). Such files are used for temporarily storing data values while the program is being run. In the PIC16F84 the file addresses that can be used for this purpose are held in Bank 0 between H'0C' and H'2F'.

In this program we could have actually placed COUNT at location H'0C' instead of H'20', but have used the later address because that is the first location available in many other PIC families, such as the PIC16F87x and PIC16F62x.

There are now two new commands illustrated in TK3TUT7, INCFSZ (INCrement File Skip if Zero) and DECFSZ (DECrement File Skip if Zero). Two allied commands, INCF (INCrement File) and DECF (DECrement File), will also be examined. The ability to increment (add one to) a value, or decrement it (subtract one from) has wide benefits in programming. Two such instances are keeping track of events through the use of counters, and of changing the values of flag bits (when in bit 0).

COMMANDS INCF AND DECF

The concept of commands INCF and DECF are extremely easy to follow. The first simply adds 1 to a file value, the other simply deducts 1 from a file value. If the file value is 255 (11111111 binary) when INCF is called, the value rolls over to zero. If the file value is zero when DECF is called, the value rolls over to 255. Whenever the result of INCF or DECF is zero, the Zero flag is set, otherwise it is cleared. Testing of the Zero flag can be performed using BTFSS or BTFSC as discussed in Tutorial 5.

Taking PORTB again as the example file, the command formats are INCF PORTB,W or INCF PORTB,F, and DECF PORTB,W or DECF PORTB,F. As previously discussed, the result of either command with a W suffix is that the new value is held in W, the file itself remaining unchanged. Conversely, the F suffix returns the new value to the file stated. Both F and W suffixes affect the Zero flag response. (Table 1 shows the flags affected by any command.)

COMMANDS INCFSZ AND DECFSZ

There are two commands which, respectively, can replace the INCF and DECF commands and which automatically test the Zero flag, taking the appropriate route depending on the truth of the answer. These commands are INCFSZ and DECFSZ, as defined at the start of this section.

Using PORTB as the example file, the command formats are INCFSZ PORTB,W or INCFSZ PORTB,F and DECFSZ PORTB,W or DECFSZ PORTB,F. If the result of any of these commands is zero, the Zero flag is automatically set, otherwise the Zero flag is cleared. The status of the flag determines the program routing in the same way as if the flag had been tested using BTFSS STATUS,Z or BTFSC STATUS,Z.

COUNTING UP AND DOWN

Listing 7 illustrates two loops, one counting up, the other down, alternating between the two after each 256 steps. INCFSZ is used in the first, DECFSZ in the second. Before entering the loops, at the label BEGIN the counter (COUNT) is cleared. Then at LOOP1 the command MOVF COUNT,W is given, followed by MOVWF PORTB.

You should now recognise what the actions do: they cause the value of COUNT to be output to PORTB. Next, the command INCFSZ COUNT,F is given, adding 1 to the value of COUNT, simultaneously checking if it has reached zero. An answer of not-zero (Z = 0) causes command GOTO LOOP1 to be performed.

Eventually, when COUNT has rolled over to zero, after 256 increments, GOTO LOOP1 is skipped (bypassed) and LOOP2 is entered where the command MOVF COUNT,W is performed, followed by MOVWF PORTB. These two lines are repeats of those at the start of LOOP1. We shall see later how duplicated lines of code can be avoided by using the code once in a sub-routine, calling it from any other routine that we wish.

Next, DECFSZ COUNT,F is performed, decrementing COUNT from the entry value of zero. COUNT thus rolls back to 255. Simultaneously, the command checks if COUNT has reached zero. If it has not, GOTO LOOP2 is performed. When COUNT has decremented to zero, command GOTO LOOP1 is performed and the cycle restarts, and so on.

It will be spotted that the use of a separate counter is not actually required in this example. We could increment or decrement the value of PORTB directly, but we are using COUNT instead to illustrate the use of a separate file to store data. We might, for example, want to increment COUNT, and then go off and do some other processing using COUNT's value, outputting that answer to PORTB instead.

EXERCISE 6

6.1. If you were to use INCF and DECF instead of INCFSZ and DECFSZ, what would be the necessary changes to the program?

6.2. What extra commands would be needed to start each loop with a non-zero value, while still counting until zero occurs?

6.3. What would happen if you had erroneously used W instead of F in one or other of the INC/DEC statements?

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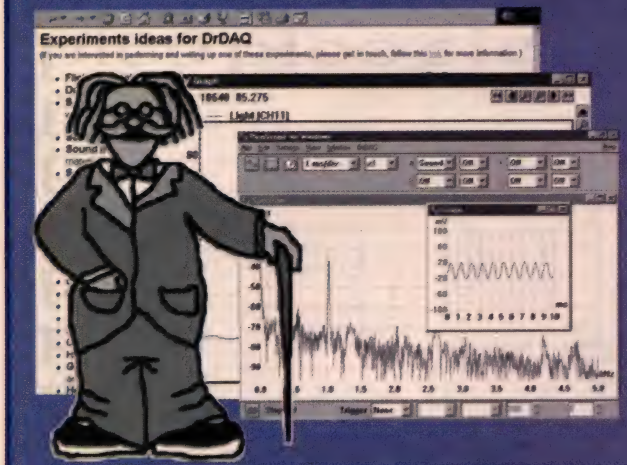

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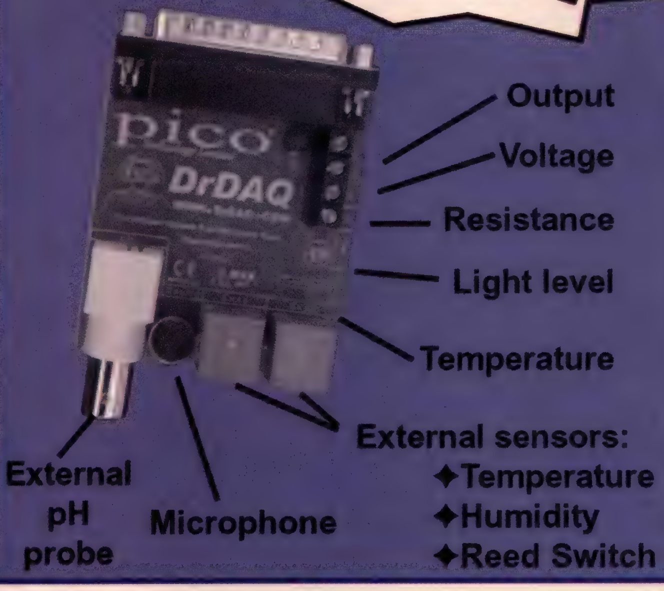

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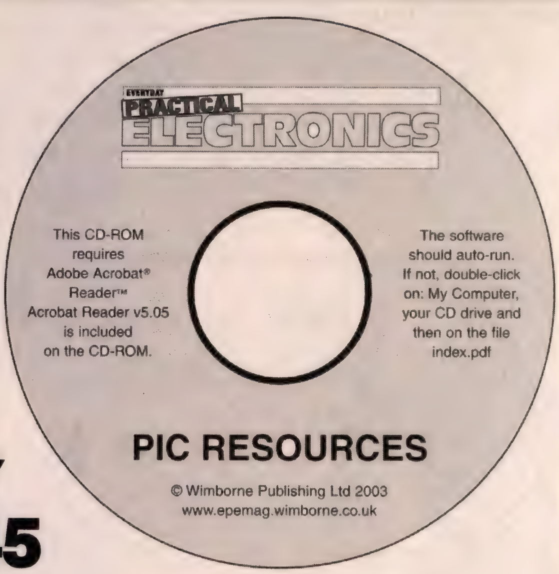
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READOUT

Email: john.becker@epemag.wimborne.co.uk

John Becker addresses some of the general points readers have raised. Have you anything interesting to say? Drop us a line!

All letters quoted here have previously been replied to directly.

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★ LETTER OF THE MONTH ★

WIND SPEED METER

Dear EPE,

I greatly appreciate John Becker's *Wind-speed Meter* article in the Jan '03 issue. Some time back, as the first step in designing an autonomous house for a difficult site (north slope, coastal Donegal), I thought that a year of local weather data would be useful. The suite of parameters I wanted is much like John's Weather Centre he's doing (but no soil moisture: there's standing water on 30° slopes during the two-week dry spell in August).

I designed an ultrasonic anemometer at the mathematical level, persuading myself that I could obtain 0·1m/s and 1° angular resolution. But our electronics lab, having been obliterated in favour of administrative offices, made no effort at construction. My current thinking favours triangular sensor placement, as in some commercial anemometers.

Creagh House (near Ballinrobe) occupied a third of an acre when it was built in 1870, but half of it burned down in 1930, and the remainder was last used as a research station by the Forestry Dept., ca. 1980. Clearing out a back room over a weekend, I came a cross a vintage cup anemometer painted in battleship grey, suitable for driving a speedometer cable down to the ground floor (or bridge, depending). With a bit of elbow grease it has become found art in gleaming copper, brass and bronze. Lovely device!

For remote data collection I have an Onset 4-input Hobo data logger, currently gathering only indoor and outdoor temperature, with a Motorola MPX4115AP barometer waiting in the wings. I still need an RH sensor – although 100% is not a bad estimate at any given time. Onset sells a "data shuttle" which carries data back to my Macintoshes, and offers free Boxcar software to process it. I then appropriate the data arrays for my own analysis and, eventually, house-management program.

The question of remote rainfall measurement with no moving parts is challenging! I belong to Nat. Uni. Ireland Galway's Environmental Change Institute, and we discuss such things carpooling to work. One approach contemplates a V-weir in the roof-drain, sensed by a capacitive level sensor – but there's the problem of compatibility with a system that collects data at prescribed times and turns on its sensors 15ms before reading them.

Onset's approach to rainfall is a separate event logger, **www.onsetcomp.com/Products/3648_event.html**, which records times from a tipping bucket. I will be very interested to see what John comes up with! (I see that Onset now sell a small weather station with cup anemometer and tipping bucket that runs for a year on four AA cells.)

As an American, I was impressed by the number of ads for prototyping boards in *EPE*, but disappointed to discover that they invariably talk to computers that I haven't touched for 20-odd years, in a language of no distinction at all. Nothing for Macs in Forth! Bizarre! (I disliked Bill Gates and his work by 1978, and have used nothing of his since. One benefit has been complete freedom from viruses; another is working software.)

Keep up the good work.

Ferren MacIntyre,via email

Hi again Ferren, many thanks for your interesting comments (and for the personal emails we exchanged!).

I'm not sure my maths is up to doing triangulated wind speed sensing, but it's an interesting thought. I'm using 4-quadrant sensing. Rain I'm intending to sense ultrasonically as well, probably a mixture of phase shift of the Ux signal and distance sensing, in relation to the surface of water in an open container. My intention is to have no moving parts whatsoever in this design. I've done mechanical weather designs in the past and now want to move on!

We principally support Gate's products as most readers have them, but we do periodically get yells of "Bill's broken my Windows again"!

DUCK OR GROUSE

Dear EPE,

Recently I read your Feb '01 Supplement on *Using Graphics LCD Displays*. The information that you have provided is excellent.

I have tried your code on a Toshiba GLCD, model TLX-1013-E0. This is slightly bigger compared to the PG12864 you used. Its resolution is 160 by 128 pixels, and it is also controlled by the T6963C. Your Demos work well on this l.c.d., except for Demo 8, which I could not get to work because I do not know how to include the **DUCK08.MSG** file using my Microchip PICStart Plus programmer. Please could you kindly advise.

For your information, the TLX-1013-E0 datasheet can be download from the Internet. I keyed in Toshiba, LCD, TLX in the Yahoo search engine which led me to the datasheet. The pins layout is slightly different from the PG12864. Furthermore, the contrast pin for TLX-1013-E0 needs about –7·5V for its display contrast setting.

Using your code directly on the TLX-1013-E0, it displays only on the upper half screen, with garbage being displayed on the lower half. The lower half screen's start address is at H8000 and the garbage can be easily cleared by your Clear routine set for this address.

Tan Lawrence, via email

I am not familiar with PICstart, Lawrence, and cannot offer you a positive opinion. However, it seems likely that it can accept data statements within ASM files for direct loading into the PIC's Data EEPROM when the main program is downloaded into the PIC. If so, you could enter the Duck data as such statements. Have a chat with Microchip via **www.microchip.com**, *or your PICstart's suppliers.*

INTERFERENCE

Dear EPE,

Regarding the *News* item about Tetra safety (Mar '03) – it is about time the makers of medical equipment, etc. got their act together. Surely they must realise that they live in the real world where spurious radiation leaks out and always will. Mobile communications equipment are a fact of life, but as usual, elementary screening precautions go out of the window in favour of cost reduction.

For example, a large London research hospital enclosed an operating theatre with chicken wire thinking it would suppress interference. It didn't, especially as there were no signal filters in the various service lines in and out, also the doors were just wood. Proof of the pudding is, if a radio works inside a room it is not screened.

Here are some instances of manufacturing stupidity: Large CCTV cameras were letting interference in because the metal lens assembly was separated from the screened box by a layer of paint. Scrape off the paint and let the lens case bind to the metal and problem solved. Hi-fi gear that just needed a tiny capacitor across the input amplifier lead to stop it pretending it was a wide band amplifier and picking up all that was there.

Some years ago an American pressure group showed a plan of cancer deaths along a microwave link path. Anybody who knows even a little bit about aerials knows that several radiation side lobes exist, yet there were no cancers marked except in the straight line between A and B. Called selective reporting I believe.

Then you see staff with mobile phones, pagers and even old fashioned walkie talkies, and ambulances outside the accident and emergency dept with powerful transmitters reporting back to base, one wonders if the whole question is not a tiny bit hyped up.

I used to be involved in the design of screened rooms and the boss wrote a book about screening problems and solutions. First line was, you can suppress anything if you have a big enough hammer.

G.S.Chatley, via email

The jury seems to be still out on all of this G.S. But even if it does come out against any form of electromagentic radiation, on the basis that it is injurious to health, could society accept and implement its judgement? Society would crash if it did. The best we can do is limit our exposure to such radiations. I for one do not wish to have a transmitter next to my brain for any longer than is necessary and only use a mobile phone when essential. It grieves me to see them in such widespread constant use, especially next to the brains of young children.

On a more mundane level, when I was still in film making, one of the recording theatres I used had problems with radio taxi transmissions breaking into the amplifier circuits. Chicken wire did solve that one, but the entire building had to be enclosed.

SERIAL EEPROM USE

Reader ***Gary Moulton*** *has kindly presented us with a software discussion, complete with example program listing, about using serial EEPROM chips with PICs. This has been placed on our FTP site in the* PIC Tricks *sub-folder of the main PICs folder, under the title* Using Serial EEPROMS.

Many thanks Gary, your gift is appreciated.

P.C.B. CAD

Dear EPE,

It seems a long time since there was a review of p.c.b. layout software in *EPE*. I haven't found it that easy to find simple, cheap, hobbyist shareware stuff by searching the web. Most trawls I try throw up heavyweight professional CAD/CAM packages which do schematic capture, multiple layers, autorouting, gerber output, and have price tags to match.

I currently use a particular p.c.b. CAD package that I bought some years ago. I've been reasonably satisfied with this software – it does most things I need it to – but the PC I run it on is beginning to show its age now. It's slow by today's standards, about one time out of three it fails to boot properly, and the incidence of funny crashes and blue screens is increasing. I fear that before too long I'm going to have to face up to the issue of replacing it, before it becomes impossible to buy PCs with serial and parallel ports on them at all.

I'm dreading this because I'm going to have to make decisions like whether to stick with Win98SE, which I run now and know fairly well despite all its shortcomings. If I do that all my existing stuff should run OK, but I'll be increasingly cut off from newer apps and interfaces that will increasingly tend to be written only for XP. Or I could change to 2000 or (heaven forbid) XP. For better or worse these are the way forward and I probably can't resist progress forever. But I'll no doubt have trouble getting some of my existing old and well-loved programs to run on a new PC, including my p.c.b. layout program. Hence I'm wondering about possible p.c.b. CAD replacements.

Maybe it would be a topic one of your regular authors might like to look at sometime.

Malc Wiles,
via email

Hi Malc, I know this is something we have discussed in private emails, but readers could be interested in a summary of the discussion.

You've hit on a bit of a thorny problem. Everyone who's into writing for EPE *will already have their own favourite p.c.b. CAD. The research time for other packages would not really be viable for them to do reviews of the various options available.*

The best advice we feel we can currently offer readers is that they obtain the free demos from those who do p.c.b. CAD and judge for themselves. It is acknowledged, though, that information about what to look out for in such packages would be highly beneficial to those who have not yet got into p.c.b. design software. Maybe this is an area that we could cover in general terms sometime. Thanks for the suggestion.

BLOWING IN THE WIND

Dear EPE,

I've read John Becker's *Wind Tunnel* article (Feb '03) as I was interested to know how he was going to control the speed of an induction motor. Not a trivial task, as he has found.

I am hardly surprised by his findings of motor characteristics at different frequencies. As most people know, mains a.c. motors are designed to run at 50Hz (or 60Hz). Below this frequency the inductive reactance of the winding gets less and less so leading to a rapid increase in current, largely limited by the d.c. resistance of the winding. Above 50Hz the inductance of the winding plays a greater and greater role in limiting the maximum current and hence maximum torque available, this coupled with increasing iron losses is why the speed actually reduces as the frequency increases above 100Hz.

Three-phase motor speed controllers (known as frequency inverters) vary the output voltage as well as the frequency and for fans the output would be set to the square law voltage/frequency curve. One of these units would actually drive a single phase induction motor of this type, but at a trade price of around £100 for the smallest of them it is obviously far too expensive for this application.

An alternative driver could be based on something similar to Thomas Scarborough's excellent *World Lamp* design (Jun '02) in which the pulse width could be made to vary with the frequency. The output waveform would be far from ideal but I see no reason why it should not work successfully, the output of smaller commercial three-phase drivers is only a very crude sine wave.

Peter Hemsley,
via email

That's interesting, Peter. I was dipping into areas unknown with the motor and was surprised at its behaviour, but assumed that torque came into it. The technique was found to be quite satisfactory for what I wanted of the tunnel.

TOUCH LAMPS

Dear EPE,

I am currently studying my A levels at Tring School in Hertfordshire. One of the subjects that I am studying is Design and Technology. My project this term is low voltage lighting and I have to research low voltage lights which will help a person work on a desk. One specific design idea that has caught my eye is touch lamps. I have searched for a long time on the internet and in electronic books and magazines for circuits.

Do you have a circuit which would make a touch lamp work? If you do, please could you email the circuit to me.

Richard Lear, via email

There are two recent designs that might interest you, Richard, one is the Touch Switch *of September '01, although it does not control a mains lamp. The other is the* Time Delay Touch Switch *of January '02.*

I hope that your teacher has impressed on you that mains powered circuits are potentially lethal and that until you are suitably experienced, you should only construct them under the supervision of someone who is qualified to handle such circuits.

It regretted, though, that even when we have information available we can never offer to send it by email. There is always a charge made for Back Issues and photocopies, and these can only be sent by post. Prices are stated on the Back Issues *page each month. Alternatively you can download recent issues for $5 (US) from our Online website.*

REAL TIME CLOCKS

Dear EPE,

Reader Andrew Jarvis asked in *Readout* Jan '03 about power saving and PIC clocks. When I was experimenting with your *PIC World Clock* (Aug '02), I found an old MT48T02B "timekeeper" RAM chip in my component drawer (Maplin's code DC01B). This could provide the answer to Andrew's problem. This RAM chip has an onboard clock, taking up the last eight bytes of its 2048 byte capacity. It will provide time keeping in years, months, days, hours, mins and secs in BCD format, accuracy ±1 sec per month. The chip has onboard lithium battery back-up for approximately ten years, so should only be a maximum of two minutes out!

If Andrew were to use a transistor as a switch in the circuit's power line and held its base on with a spare PIC I/O port, a simple timing routine could turn off the whole circuit (a sort of PIC suicide switch!) – *no* power drain on the main battery and clock functionality carries on. A pushbutton "starter" on the transistor's base would boot the lot up again. With nearly 2K of RAM left, recordings could be made of any data wanted just before the "kill".

As is life, though, you don't get something for nothing. On-state power consumption goes up, as does the cost!

Graham Card, via email

Hi again Graham, thanks for the info, which I sent on to Andrew when I received your email.

WELL SCORED!

Dear EPE,

Many years ago, longer than I care to think about, I transferred from what used to be *Practical Wireless* to *EPE*, buying copy number one. I pursued the hobby, building all kinds of interesting constructional projects, including the first ever *Teach In* that launched me on to my career in a branch of electronics. My hobby became my job, so somewhere along the way I am afraid I no longer did my projects or, to my regret, read the magazine.

Having lost the art of doing Project Construction now that I am retired, and needing some construction knowledge, I searched the bookstall looking for *EPE*, and I was just thrilled to find it, and that you have looked after it wonderfully well, it's just as I left it. You now have an old (old) reader back.

I am hoping that you or your contributors may be able to help. I run a quiz, and would like to make a score display that could be advanced by increments of 1 or reduced by 1 (to overcome any mistakes). I had in mind a 7-segment display possibly about 50mm high that would count to 99. Any offers?

John Reynolds, Peterborough. via email

Welcome back John! I too am fascinated by electronics and many years ago had to make the choice about whether or not to make my hobby my job – well, you know the answer!

Your idea should not be difficult to implement, although I can't offer to design one for you, but by quoting your letter here it might inspire a reader to do so and offer it to us.

BABEL FISH?

Dear EPE,

I am a student and looking for a Sonar Fish Finder circuit to construct as my project. Can you help?

Kyaw Swa Thant,
via email

I replied direct saying we had not done anything like this and suggested Kyaw asked his question via our Chat Zone (entry via top link on our Home page at **www.epemag.wimborne.co.uk***). Just for a bit of lightheartedness, here are extracts from the CZ offerings that resulted:*

E-friend John Waller comments that "Fish don't make much noise, they are interested in surviving."

Jez Smith (what refreshment are you on Jez?!) says, "I have visions of an ickle cat in a glass box, you lower the box into the water and wait till the cat tries to catch the fish. Depending on which way the cat looks the weight shifts and you can detect that and display it."

While Boris wants to know, "What do Sonar Fish taste like?"

Kyle Curre came back on that one with "I imagine Sonar Fish tastes a tad like Infra-red Fish, with that sort of 40kHz vibration tingling on your tongue. Here's your fish-finding circuit: 1000V a.c., into the water. The fish pop to the surface, and pow! You've found them. Now take a laptop with a graphics tablet and draw it on the l.c.d.".

With a return posted by Boris – "As a boy, one of my 'inventions' was an automatic goldfish bowl cleaning system. It was basically just two large-surface-area electrodes, one at either end of the tank with a small d.c. potential across them. Theory being that the 'dirt' will collect on the anode and keep the water clear. Of course, the first time I tested it, both the fish were instantly electrocuted. I kind of lost the will to keep fish after that . . .

And before any Hitch Hiker fan asks – no, a Sonar Fish is not a relative of the Babel Fish!

What reader Kyaw Swa Thant appears to be looking for is a circuit for a device that transmits an ultrasonic signal (sonar) whose returned echoes are processed to show on a display screen the presence of submerged objects that might be fish. Commercial fishing boats use them.

Does anyone have a sensible answer to offer?!

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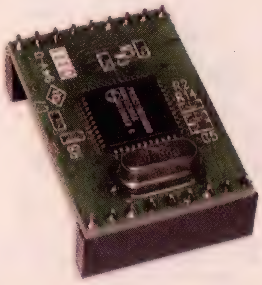

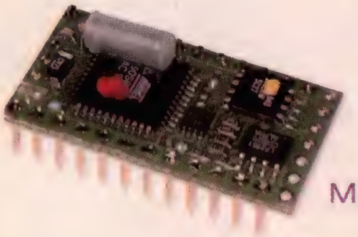

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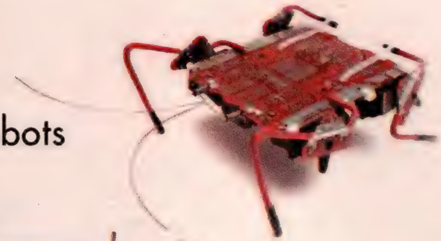

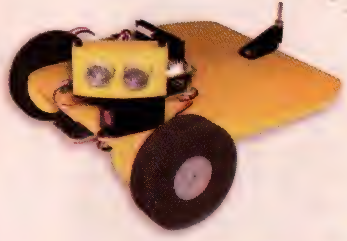

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Output current	0-3A	2 x 0-3A	2 x 0-3A, 3A	0-10A	0-20A
Load regulation	<0·01%	<0·01%	<0·01%	<0·02%	<0·02%
Ripple & noise	<1mV rms	<1mV rms	<1mV rms	<3mV rms	<3mV rms
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SHOP TALK

with David Barrington

Earth Resistivity Logger

Nearly all the major components needed to construct the *Earth Resistivity Logger* project came from **RS Components** and can be ordered through any *bona-fide* stockists, including some of our advertisers. If a local source proves to be elusive, you can order direct (*credit card only*) from RS on ☎ ***01536 444079*** or through the web at ***rswww.com***. A postage and handling charge will be made.

The two-part case, with transparent lid, used in the prototype came from RS and is coded 507-668. However, during prolonged field surveys it was found that the specified battery "life" was short-lived and it is suggested that a larger size case be used to take a more substantial 9V battery pack.

The above-mentioned company also supplied the ICL7660 voltage inverter, code 427-304, and the RS-232 interface driver type MAX232, code 655-290. Although both devices should be readily available from components advertisers.

We only found one listing for the 24LC256 256 kilobit serial EEPROM memory chip, and that was **Farnell** (☎ ***0113 263 6377*** or ***www.farnell.com***), code 300-1696.

For those readers unable to program their own PICs, a ready-programmed PIC16F876 microcontroller can be purchased from **Magenta Electronics** (☎ ***01283 565435*** or ***www.magenta2000.co.uk***) for the inclusive price of £10 each (overseas add £1 p&p). They also supplied the 2-line 16-character (per line) alphanumeric l.c.d. module.

The software is available on a 3·5in. PC-compatible disk (Earth Resistivity) from the *EPE Editorial Office* for the sum of £3 each (UK), to cover admin costs (for overseas charges see page 299). It is also available for free download from the *EPE* ftp site, which is most easily accessed via the click-link option at the top of the home page when you enter the main web site at ***www.epemag.wimborne.co.uk***. On entry to the ftp site take the path **pub/PICS/EarthRes**, downloading all files within the latter folder.

Finally, the printed circuit board is available from the *EPE PCB Service*, code 388 (see page 299).

Intelligent Garden Lights Controller.

Apart from the PIC microcontroller and associated software, the only other component listed in the *Intelligent Garden Lights Controller* project that is likely to cause concern is the switching relay. The miniature 12V d.c. coil, p.c.b. mounting, relay used in the model has switching contacts rated at 16A 250V a.c. and was purchased from **Rapid Electronics** (☎ ***01206 751166*** or ***www.rapidelectronics.co.uk***), code 60-4620. Extra holes have been drilled in the circuit board to cater for other possible p.c.b. mounting types.

If you wish to use the identical low-profile pushbutton switch, this came from the above company, code 78-1520. They also supplied the miniature 5mm dia. light-dependent resistor (l.d.r.), but these should be generally available.

A pre-programmed PIC16F627 (PICAXE-18) microcontroller can be purchased (*mail order only*) from ***M. P. Horsey, Electronics Dept, Radley College, Abingdon, Oxon, OX14 2HR***, for the inclusive sum of £5.90 each (overseas add £1 p&p). Make cheques payable to ***Radley College***. It should be noted, however, that readers who wish to modify the BASIC program to suit their own requirements need to use the PICAXE programming software and serial lead that is only available from **Revolution Electronics, Dept *EPE*, 4 Old Dairy Business Centre, Melcombe Road, Bath BA2 3LR. Tel: 01225 340563. Web: www.rev-ed.co.uk.** (This software is ***not*** available from *EPE*).

The BASIC and hex files are available for free download from the *EPE* ftp site. This is accessed via the main page of the *EPE* web site at **www.epemag.wimborne.co.uk**. At the top is a click-link saying **FTP site (downloads)**, click it then click on **PUB** and then on **PICS**, in which screen you will find the Garden Lights folder.

The software can also be obtained on a 3·5in. disk (Disk 6) from the Editorial office. There is a nominal handling charge to cover admin costs and details are given on page 299.

The printed circuit board is obtainable from the *EPE PCB Service*, code 389 (see page 299).

Atmospherics Monitor

We have not been able to establish a supplier for the 200mm length of ferrite rod for the *Atmospherics Monitor* project. One possibility might be **J&N Factors** (☎ ***01444 881965*** or email ***jnfactors@aol.com***), who sometimes acquire ferrite rod aerials which they offer at a very reasonable price. Alternatively, readers may need to adopt the author's suggestion and glue two 100mm rods end-to-end.

The 250μA signal strength panel meter (code LB80B) and the piezo sounder (code FM59P) both came from **Maplin** (☎ ***0870 264 6000*** or ***www.maplin.co.uk***). The LM358 dual op.amp is a very common device, but the author suggests the National Semiconductors op.amp be used here. Obviously, the "plumbing" parts will be found at any DIY superstore.

Back-To-Basics 3 – Touch Light/Plant Watering Reminder

We do not expect readers to experience any buying difficulties when shopping for components for the two projects in this month's instalment of the *Back-To-Basics* series.

PLEASE TAKE NOTE

Digital I.C. Tester *(Oct/Nov '02)*
Updated software is now on our ftp site.

PIC Toolkit TK3 *(Nov '01 – Supplement)*
Software version V1.4, including source code, is now on our ftp site (it is the same as that on the *PIC Resources CD-ROM – see page 270*).

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Board cameras all with 512 x 582 pixels 8·5mm 1/3 inch sensor and composite video out. All need to be housed in your own enclosure and have fragile exposed surface mount parts. They all require a power supply of between 10V and 12V DC 150mA.
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40MC size 39 x 38 x 27mm camera for 'C' mount lens these give a much sharper image than with the smaller lenses £32.00 + VAT = **£37.60**
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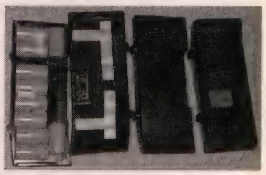

866 battery pack originally intended to be used with an orbitel mobile telephone it contains 10 1·6Ah sub C batteries (42 x 22 dia. the size usually used in cordless screwdrivers etc.) the pack is new and unused and can be broken open quite easily
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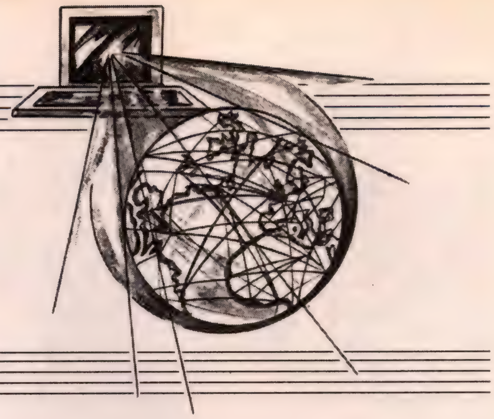


NET WORK

ALAN WINSTANLEY

A Virtual Industry

LAST month, the popular online auction site eBay (**www.ebay.com** or **www.ebay.co.uk**) was introduced for the benefit of those who are relatively new to Internet usage. Ebay is a wonderful way of selling merchandise that is too good to throw away, and there is a good feeling to be had in selling your wares knowing that it is going to a good home. This month's *Net Work* offers more practical tips to help you get the best out of online auctioneering, partly because it follows the writer's best Yorkshire tradition of not spending more brass (money) than he ever needs to!

After registering your details online with eBay, you are ready to bid or sell online, and there are many "eBayers" who run a cottage industry by trading through their web site. You can sell through them for a modest commission that eBay will deduct directly from your current account a few weeks later.

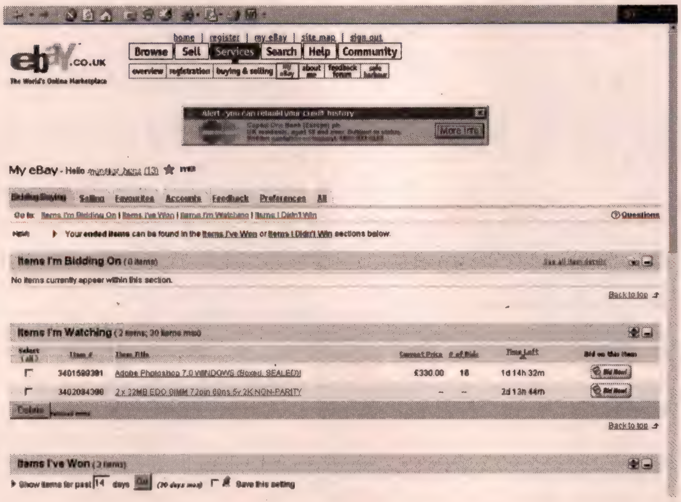
When it comes to buying, eBay provides its members with a "My eBay" web page (see screenshot) where you can store items to monitor the bidding and keep track of your purchases. The My eBay page forms the hub of all your transactions. Two buying options are provided, sometimes "Buy It Now" lets you offer to buy on the spot, but usually an auction will take place lasting for anything up to ten days. (If you're selling, it is worth using a ten-day period, also trying to ensure that two weekends are included to improve your chances of selling.)

When browsing for bargains, it pays to get a good feel for prices before getting carried away, but it's no secret that some really juicy bargains can be had, if you play your cards right. Decide on a maximum price, and maybe add 5% as a safety margin.

Beware of Bargains

There are plenty of genuine traders, but if some items are listed very cheaply and you think there must be a catch, there almost certainly is, so you need to follow your instincts. In the case of computer software for example, it stands to reason that if an expensive product such as Adobe Photoshop 7, which retails at £530 ($820), is being sold on eBay for only £10 "to be used for backup purposes only" then there is a good chance that a CD-writer has got in the way somewhere along the line.

Casting a keen eye over the descriptions and seller's ratings can yield some genuine bargains: brand new, shrink-wrapped Photoshop 7 for well under £300 is a bargain, especially if it can be registered with the software company. The author sourced a whole suite of genuine new Adobe software this way for less than half price.



My eBay - Hello

Your ended items can be found in the Items I've Won or Items I Didn't Win sections below.

Items I'm Bidding On (0 items)

No items currently appear within this section.

Items I'm Watching (2 items; 30 items max)

Select (all)	Item #	Item Title	Current Price	# of Bids	Time Left	Bid on this Item
☐	3401580381	Adobe Photoshop 7.0 WINDOWS (Boxed, SEALED)!	£330.00	18	1d 14h 32m	Bid Now!
☐	3402084398	2 x 32MB EDO SIMM 72pin 60ns 5v 2K NON-PARITY	–	–	2d 13h 44m	Bid Now!

Items I've Won (3 items)

Show items for past 14 days (30 days max) ☐ Save this setting

The configurable "My eBay" page forms the hub of online bidding, allowing users to monitor auctions and bids.

If you really don't need the latest and greatest of computer hardware, there are plenty of used bargains available, remembering that although you have a right to expect goods to be described accurately, there will probably be no guarantee provided.

Good Technique

There is a definite technique for buying online at the best price. Let's take Adobe Photoshop 7 again. In the past week or two, a number of new shrinkwrapped copies came up for sale that eventually sold for about £260 to £280.

Another copy came up on a ten-day auction and users immediately started bidding for it, eager not to miss out this time around. At the time of writing the price has already reached £330 and there is still a week to go!

It is a mistake to show an interest too early, because it just stokes up the price and highlights the competitive level of interest. Instead, choose to watch the item on your "My eBay" page for a few days to see how it's going, and also search for similar items on sale at the same time.

Also remember to check an item's payment options carefully, so that you don't trap yourself into paying, for example, by Paypal if you are not a registered user. Paypal (**www.paypal.com**) is a very popular way of accepting credit cards online, and it is fully integrated into eBay. Check the Paypal web site closely for details of the registration process, which can take up to 30 days to complete, as it requires verification of a nominal test entry on your credit card statement.

Snipe a Bargain

As mentioned last month, eBay uses a system it calls proxy bidding, so you can enter a maximum bid in the knowledge that you could actually win for much less, if no-one else bids. Bidding is raised in fixed increments (say £2 or £5). By timing your maximum bid correctly, you could enter a value that you are sure no-one else will want to beat (say £350 for Photoshop 7); you then become the highest bidder, *but your actual price will only be one increment above the current price* (say £285).

In this way, then if no-one else bids, you can win an auction by pricing everyone else out of the market, because they would have to exceed your maximum bid (in which case, they're welcome to it). However, having forced up the price, someone could still outbid you and win by as little as one penny. It can be an exciting if not nerve-wracking experience, watching the bids suddenly mount up at the last moment.

Seconds Out

This is a crucial aspect of bidding: an "eBay-savvy" user will only bid in the closing moments of an auction. If you are struggling on ordinary dial-up Internet access, then you have no hope of refreshing your screen in time to fetch the latest bids, so you cannot usually enter a higher bid in the closing seconds of an auction.

On several occasions the writer has hoped to win a particular auction, only to be outbid in the last ten seconds or less, and with the clock ticking by, the auction has ended (they are literally timed to the second) before another bid could be entered. This last-minute winning bid is called *sniping* and it can be very aggravating!

Next month: How to become an eBay auction "sniper", and how you can suddenly start to win one auction after another by entering a trumping bid with just three seconds left before the auction closes!

You can email me at **alan@epemag.demon.co.uk**.

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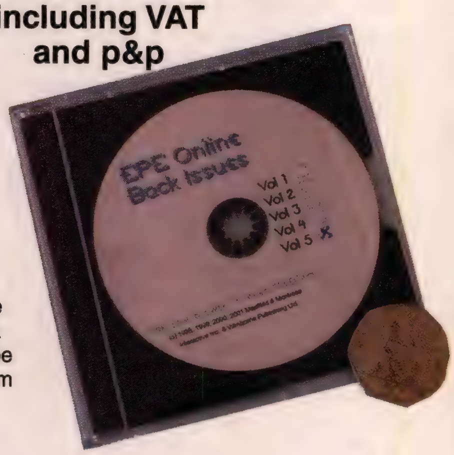

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M04/03

Constructional Project

BACK TO BASICS

BART TREPAK

Part Three

Illustrating how useful circuits can be designed simply using transistors.

TOUCH LIGHT

THERE are many places around the house where a small light would be useful but running a mains cable to the location is impractical. Corners of dark cupboards, over the telephone to light a note pad, by the front door to help find the keyhole at night, are just some of the applications which come to mind.

None of these require very much light and high brightness light emitting diodes (l.e.d.s) can not only provide the illumination needed, but can also be readily fitted with a time delay circuit so that they switch off automatically, so saving battery power. The circuit described here offers such a solution. It is shown in Fig.18.

To ensure that the circuit switches off after use and prevent having to change the battery too often, a timing circuit is required. For this a monostable configuration is used. A monostable has one stable state, in this case the *off* state. When triggered into its *on* state, it will remain in that state for a preset period before switching off again.

Some circuits of this type use two transistors (*npn* or *pnp* types) configured so that in the stable state one transistor is on while the other remains off. Following a trigger pulse, both transistors change state. A disadvantage of this circuit is that during the off state, one of the transistors is always turned on, and so consuming power.

An alternative configuration is used here in which all transistors remain off when the circuit is in its stable state, so consuming virtually no current.

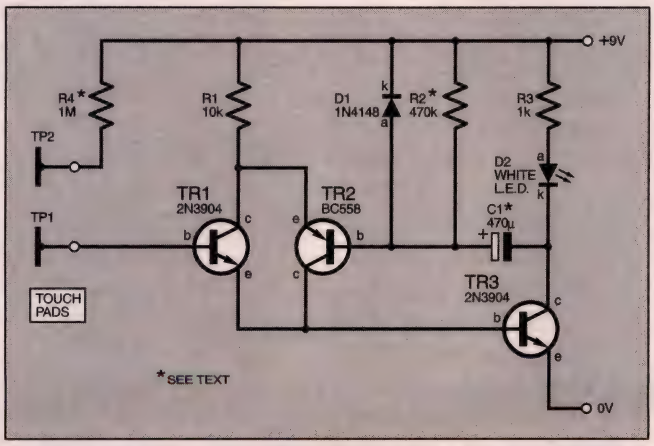


Fig.18. Circuit diagram for a three-transistor Touch Light.

TOUCH CIRCUIT

In the circuit diagram shown in Fig.18, transistors TR2 and TR3 form the monostable circuit, with capacitor C1 and resistor R2 determining the time for which the transistors remain on once the circuit has been triggered.

This occurs when finger contact is made with touch pad TP1. The 50Hz mains "hum" normally present in all households will be induced into the circuit through the finger, causing transistor TR1 to turn on. This provides base current to TR3, turning it on, together with the l.e.d. (D2), whose current is buffered by resistor R3.

When the collector of TR3 goes low, a negative-going pulse is generated across capacitor C1, causing TR2 to turn on and provide more current to the base of TR3. When the contact with TP1 is broken, TR1 ceases to conduct, but TR3's base continues to be held on via TR2. However, C1 starts to charge via resistor R2. Eventually, its charge rises to within less than 0·6V of the positive power supply, turning off TR2 and thus TR3 and the l.e.d. as well. Diode D1 inhibits any positive-going pulse generated across C1 when TR2 switches off.

With the component values shown, the l.e.d. will remain on for about three minutes.

TOUCH-DOWN

It is worth noting that touch pad TP2 may be needed if the 50Hz mains "hum" introduced by finger contact with TP1 is not strong enough, or non-existent, as in a garden shed for example. Making finger contact between TP1 and TP2 causes a small current to flow from the positive line, though the finger and into the base of TR1. It is advisable to insert resistor R4 between TP2 and the positive line to prevent damage to TR1 should the two pads be shorted accidentally by an object with a low resistance.

If the unit is found to be too sensitive, a high value resistor of about 10MΩ can be connected from the base of TR1 to the battery negative. This will prevent the circuit from switching on inadvertently, especially in areas where the mains field is high.

COMPONENTS

See SHOP TALK page

Resistors

R1	10k
R2	470k (see text)
R3	1k
R4	1M (see text)

Capacitor

C1	470µ axial elect. 16V (see text)

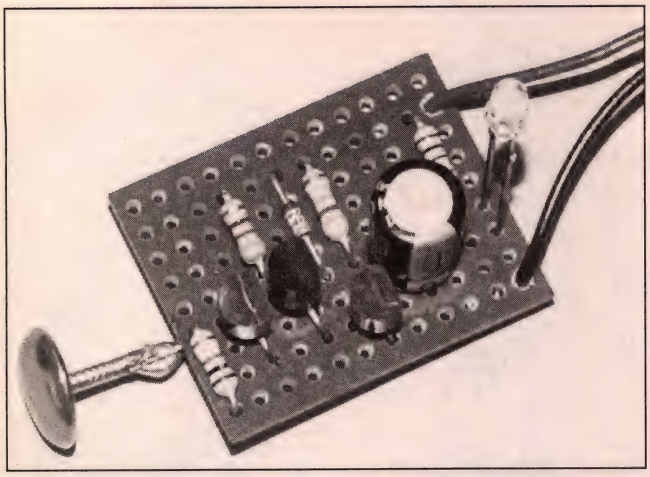
Semiconductors

D1	1N4148 signal diode
D2	white l.e.d., high brightness (see text)
TR1, TR3	2N3904 *npn* transistor (2 off)
TR2	BC558 *pnp* transistor

Miscellaneous

Stripboard, 8 strips x 12 holes; touch pad(s) (see text); case to suit; connecting wire; 9V battery, with holder and clips; solder, etc.

Approx. Cost Guidance Only **£4** *excl. case and battery*



Prototype Touch Light circuit board. The additional resistor seen bottom left is not required in this circuit.

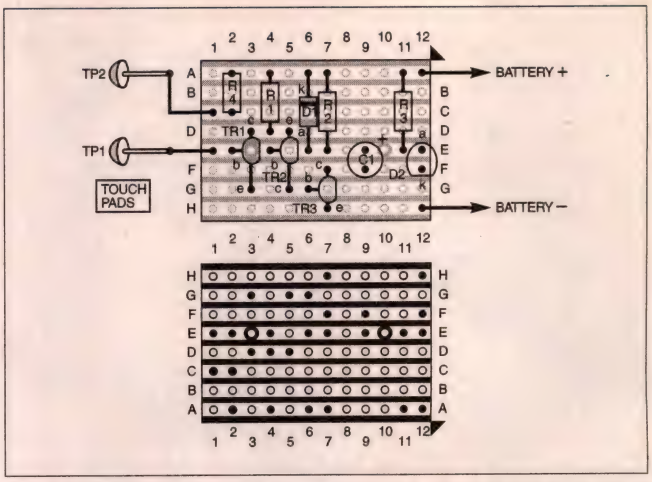


Fig.19. Stripboard component layout and underside copper tracks showing two cuts in strip E.

CONSTRUCTION

The circuit is built on a small piece of stripboard having 12 holes by 8 strips, as shown in Fig.19. Only two track cuts need to be made and no wire links are required. Apart from the resistors, all other components must be inserted the correct way round.

Power to the circuit should be supplied by a 9V battery. As the stand-by current is extremely low (basically the leakage current of the transistors), the expected life should be almost the shelf life of the battery, depending of course on how often it is switched on. Consequently, an on/off switch is not required.

The finished unit should be mounted in an insulated plastic box of a size suitable for the battery and circuit board. The touch contact(s) can be made from any piece of metal such as a bolt or nail, but a drawing pin pushed through a suitable hole in the box and connected to the board via a short length of wire provides a neater, more attractive finish.

L.E.D. CONSIDERATIONS

When on, the total current is 6mA with the l.e.d. accounting for about 5·8mA. White l.e.d.s exhibit a forward voltage drop of around 4V, so two could be used in series to provide more light. Resistor R3 would then need to be reduced to 470Ω to maintain the l.e.d. current at around 5mA.

The brightness of the l.e.d.(s) can be increased by reducing the value of R3 to increase the current flow. Do not allow the current to be greater than that permitted by the l.e.d., which should be stated in its data sheet and supplier's catalogue. There appears to be little apparent increase in brightness beyond about 10mA.

Data sheets normally quote an l.e.d. viewing angle and this describes the "off axis" brightness of the device. Unlike the filament in a light bulb, an l.e.d. chip emits light only from its surface, rather than all around, so the light comes mainly from the front of the device. This is modified to some extent by the plastic package and l.e.d.s are available with a more or less focused light beam. Depending on the use, a wider angled light pattern may be preferred.

PLANT WATERING REMINDER

HOUSE plants in general often have a pretty hard time of it compared to their garden bound cousins, which seem to get more than their fair share of watering, even if their owner forgets, thanks to the British weather. With so many other things to think about, the first reminder that many people get to water their plants is when it is noticed that one or two are wilting or the leaves are turning brown and dropping off!

Modern central heating also ensures that the soil in pots dries out much faster, making regular watering more important, so that a little electronic help in remembering to do so should be most welcome.

CIRCUIT DIAGRAM

The circuit suggested here, and shown in Fig.20, drives a piezo sounder, WD1, to provide a timely warning that the soil in the plant pot is almost dry.

Hopefully, the plants will be watered regularly so the alarm will remain off but it may become active at any time and it is unlikely that the plants will be watered immediately as the owner may be out. It may therefore continue to sound all day before the plants are watered. To avoid having to replace the battery too often, it is important to ensure that the current drain in either condition is as low as possible.

To minimise the current drain during the alarm condition, a complementary astable circuit built around transistors TR2 and TR3 is used. Its operation is beyond the scope of this article, but it oscillates with a frequency determined by resistor R2 and capacitor C1. With the component values given the frequency will be about 2kHz, producing a fairly loud sound from piezo sounder WD1. This device has a very high impedance and so a load resistor, R3, is provided for TR3.

Since both transistors switch on and off together and remain off for a relatively long period (dependant on the value of R2) compared to the time when they are on, the average current drawn from the battery is very low, at about 1mA.

The output consists of short positive going pulses which turn on the piezo sounder WD1. The operation of the oscillator is controlled by TR1. When this transistor is on, the base of TR2 is held low and the circuit cannot oscillate.

The circuit relies on sensing the resistance of the soil between two metal probes which are inserted into the pot close to the plant. Completely dry soil will have a relatively high resistance but this will fall as the moisture content is increased.

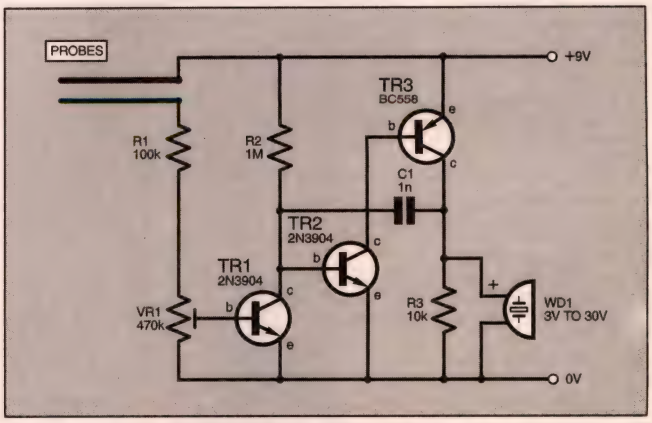
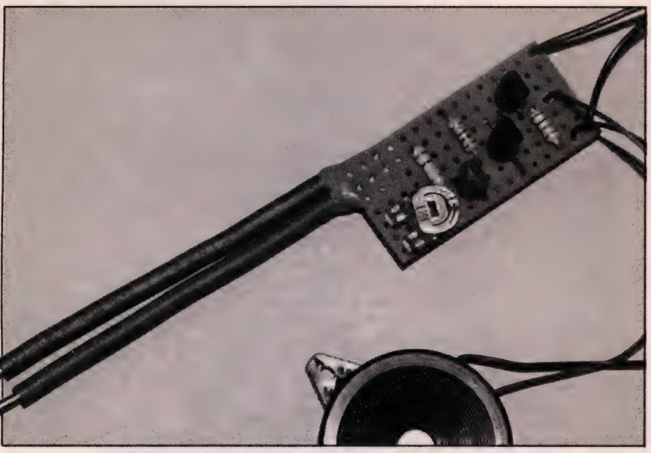


Fig.20. Circuit diagram for the Plant Watering Reminder.



Completed Plant Watering Reminder circuit board. The probes have been covered with plastic sleeving, except their tips.

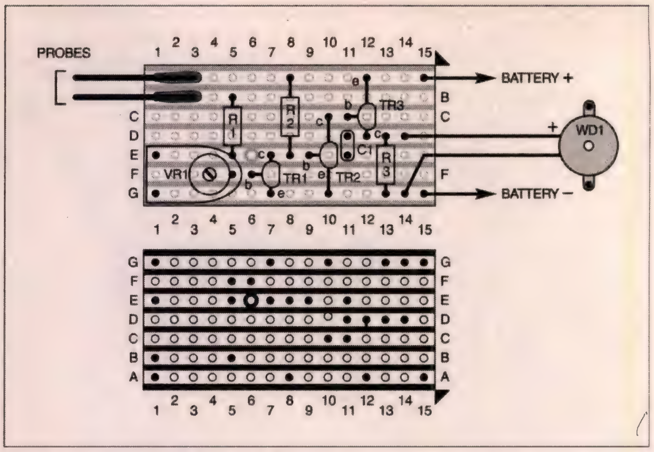


Fig.21. Plant Watering Reminder component layout; only one copper track break is needed.

The series resistance of the probes, resistor R1 and potentiometer VR1 form a potential divider across the supply. With the soil moist, the resistance of VR1 can be adjusted so that the voltage at the base of TR1 is at 0·6V, ensuring that this transistor is switched on and so disabling the oscillator.

As the soil dries out, the base-emitter voltage of TR1 falls to a point at which it switches off sufficiently to allow the oscillator to function, producing an audible warning.

As described earlier, this circuit produces short output pulses and therefore draws only a small current when it is oscillating (about 1mA).

In the stand-by condition when the oscillator is switched off, the current drain on the battery is only 10μA, so the battery should last a long time.

CONSTRUCTION

The circuit is built on a piece of stripboard having 7 strips × 15 holes, as shown in Fig.21. Only one strip cut is required and there are no link wires. Care should be taken to ensure that the transistors and the sounder are connected the correct way around.

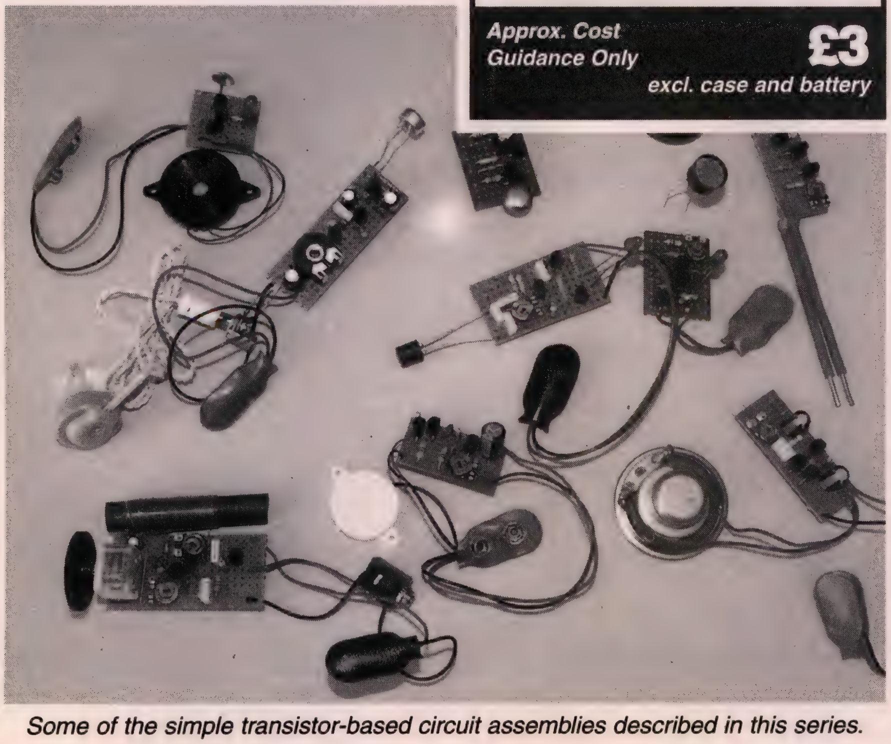
COMPONENTS

See SHOP TALK page

Resistors	
R1	100k
R2	1M
R3	10k
Potentiometer	
VR1	470k min. skeleton preset.
Capacitor	
C1	1n ceramic disc, 2·5mm pitch
Semiconductors	
TR1, TR2	2N3904 *npn* transistor (2 off)
TR3	BC558 *pnp* transistor
Miscellaneous	
WD1	3V to 30V piezo sounder

Stripboard, 7 strips x 15 holes; PP3 battery and clip; stout metal probes (see text) (2 off); case to suit, connecting wire; 9V battery, with holder and clips; solder, etc.

Approx. Cost Guidance Only **£3** *excl. case and battery*



Some of the simple transistor-based circuit assemblies described in this series.

The probes consist of two stiff metal wires the length of which is not particularly important and will depend to a large extent on the size of the pot into which the unit is placed. Copper is perhaps the easiest wire to get hold of (and to solder).

In the prototype, two 10cm lengths of 2·5mm diameter rigid wire of the type used in house wiring were used. These were soldered directly to the tracks at the positions shown, the wire being too thick to pass through the holes in the board.

Since these are liable to break off if the probes are pushed into hard earth, it is probably best to solder the wires directly to the copper tracks straddling several holes. This may then be strengthened by covering the joints and an adjacent area of the board with epoxy glue. Alternatively, the wires may be mounted a few millimetres apart on an insulating surface, such as the plastic box in which the unit is to be placed, and connected to the board by flying leads.

SOUNDLESS ALARM

When completed, place the probes in moist soil close to the roots of the plant. Set VR1's wiper to a fully anti-clockwise position, and then adjust it until the circuit just fails to oscillate. Should the alarm sound as the soil dries out but it is still judged to be too moist to require watering, VR1 should be turned further clockwise.

In some situations, an audible alarm may not be desirable, in which case the sounder can be omitted, and an l.e.d. plus ballast resistor of about 470Ω can be wired in place of R3, with the anode (a) connected to transistor TR3's collector, and the other side of the 470Ω resistor on the 0V line. Omit R3 itself. Do not use the l.e.d. without the ballast resistor as the current through it cannot be guaranteed to be within its limits, even though the current is pulsed.

The sounder and l.e.d. may both be fitted, although this will result in a slightly increased current consumption and a slightly reduced sound output, but should still be adequate for most situations.

NEXT MONTH

In the next issue we present a Live Wire Detector that safely locates the presence of mains electrical circuits, plus a simple MW Radio.

New Product

Atlas *LCR* Passive Component Analyser (Model LCR40)

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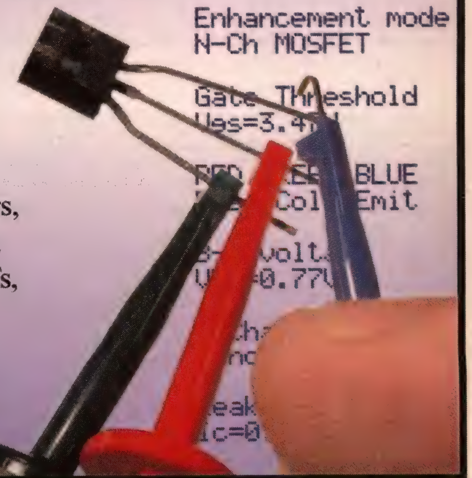

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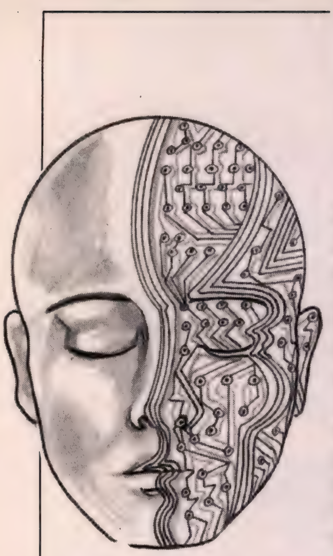

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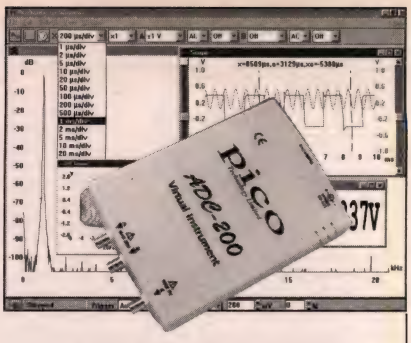
Our regular round-up of readers' own circuits. We pay between £10 and £50 for all material published, depending on length and technical merit. We're looking for novel applications and circuit designs, not simply mechanical, electrical or software ideas. Ideas *must be the reader's own work* and **must not have been submitted for publication elsewhere.** The circuits shown have NOT been proven by us. *Ingenuity Unlimited* is open to ALL abilities, but items for consideration in this column should be typed or word-processed, with a brief circuit description (between 100 and 500 words maximum) and full circuit diagram showing all relevant component values. **Please draw all circuit schematics as clearly as possible.**
Send your circuit ideas to: *Ingenuity Unlimited,* Wimborne Publishing Ltd., 408 Wimborne Road East, Ferndown Dorset BH22 9ND. (We **do not** accept submissions for *IU* via E-mail.) Your ideas could earn you some cash **and a prize!**



WIN A PICO PC BASED OSCILLOSCOPE WORTH £586

- 100MS/s Dual Channel Storage Oscilloscope
- 50MHz Spectrum Analyser
- Multimeter • Frequency Meter
- Signal Generator

If you have a novel circuit idea which would be of use to other readers then a Pico Technology PC based oscilloscope could be yours. Every 12 months, Pico Technology will be awarding an ADC200-100 digital storage oscilloscope for the best IU submission. In addition, a DrDAQ Data Logger/Scope worth £69 will be presented to the runner up.

Three-State Vehicle Probe – A Positive Response

THE simple probe circuit of Fig.1 was designed for use in tracing 6V or 12V vehicle wiring. Basic probes have a crocodile clip which is connected to ground (chassis) while a single bulb or l.e.d. illuminates when the probe makes a positive connection. If the indicator does not light up, then the probe is assumed to be making a ground connection.

This circuit is intended to remove the ambiguity of that assumption by providing a clear indication of the three following states:

1 – A red l.e.d. will illuminate to indicate a "positive" connection.

2 – A green l.e.d. will illuminate to indicate a "ground" connection.

3 – A yellow l.e.d. will illuminate to indicate "no connection" (floating condition).

With no connection to the probe (i.e. floating input), l.e.d. D3 (yellow) will be switched on via NAND gate IC1b which will have a "high" applied to each of its inputs (pins 5 and 6), making the gate's output go "low".

Should the probe make contact with 0V (ground) then transistor TR1 will be switched off which drives the output of IC1a low, thus illuminating l.e.d. D2 (green). Simultaneously IC1a will apply a low to pin 5 of gate IC1b, causing its output to go high, therefore extinguishing yellow l.e.d. D3.

When a positive input is applied to the probe, TR2 will switch off causing IC1c output to go high. This output is inverted by IC1d and switches on D4 (red). At the same time, the output of IC1d is also taken to pin 6 of IC1b, which then extinguishes the yellow l.e.d. D3.

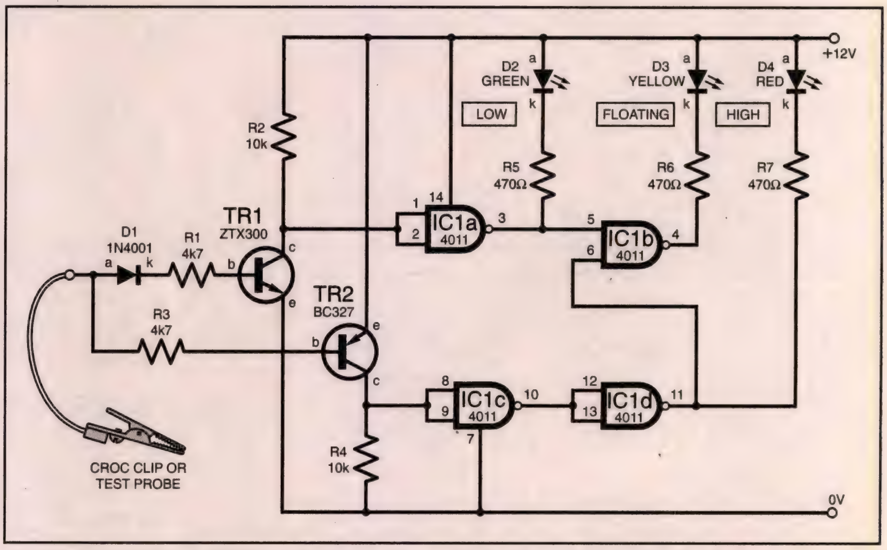


Fig.1. Circuit diagram for the Three-State Vehicle Probe.

A supply for the circuit was obtained from the vehicle's cigar lighter socket, or you could use a fused 12V lead to clip onto the car battery terminals, placing the fuse as near as possible to the battery's positive pole.

T. J. Heaney, Northallerton

PCB Drill Controller – A Bit More Action

AFTER buying a small low voltage drill for working on printed circuit boards, it was noticed that the drill motor would stall if the input voltage was less than 15V. This voltage resulted in a higher power but also a higher drill speed which increased the heat and wear on the drill bit, rapidly making it blunt.

The circuit diagram shown in Fig.2 uses pulse control to decrease the drill speed while maintaining the output power. IC1a is one half of a 556 timer and is set in astable mode to provide a base frequency of approximately 150Hz. This is fed into IC1b which triggers the monostable, set by Speed potentiometer VR1 to have a period of between 0·1ms to 10ms.

The duration of the monostable determines the period that the drill motor has the full 15V potential across it, and hence the speed of the drill which is lowest when the time period is 0·1ms. The output of IC1b is connected to the base of transistor TRl which is a high current (3A) power transistor that controls the load. It is protected from inductive voltage spikes by diode D1. The circuit proved to be very effective and can be powered from an existing 12V to 15V d.c. drill power supply unit.

Daniel Salt, Hunstanton, Norfolk

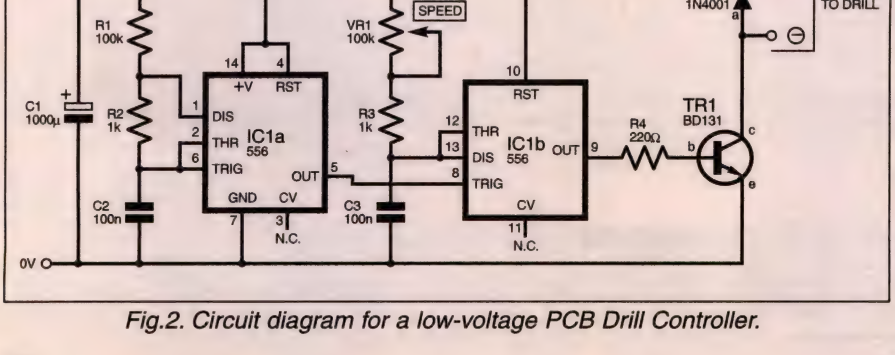


Fig.2. Circuit diagram for a low-voltage PCB Drill Controller.

StyloQIC – To The Point

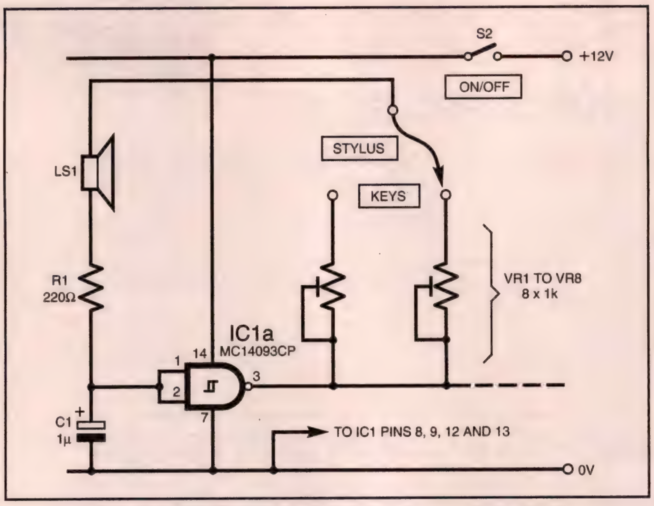


Fig.3. Circuit diagram for the basic StyloQIC.

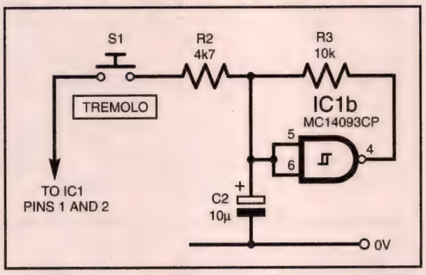


Fig.4. Adding a Tremolo function to the StyloQIC circuit.

THE circuit diagram shown in Fig.3 was inspired by the *EPE StyloPIC* design (July '02 issue) and is a minimalist "Stylophone" that is "QIC" to build!

It uses just 14 components to play two octaves. In addition, it sports an optional tremolo or frequency modulation feature. It uses virtually zero current on standby, and therefore requires no on-off switch.

The oscillator, based upon IC1a, may be likened to a conventional *RC* Schmitt oscillator, except that *R* is replaced with an inductor. The inductor works by opposing electrical pulses (inductive reactance), thus impeding the charge and discharge of capacitor C1. If a pair of headphones or a miniature speaker (LS1) is used for the inductor, a good audible tone is heard.

Resistor R1 limits back e.m.f. across the gate's inputs and output to help protect IC1a. Preset potentiometers (wired as variable resistors) VR1 to VR8 are all one kilohm (1k) types that adjust the pitch of eight notes individually. If an additional 1kilohm preset is inserted at IC1a output using push-to-make pushbutton switch S1 wired in parallel, the pushbutton will provide one additional octave.

The circuit diagram of Fig.4 is an add-on Tremolo function. This *RC* oscillator modulates the frequency of IC1a as the voltage across capacitor C2 rises and falls. Since this rapidly raises and lowers the set frequency of each note, it does not change the fundamental frequency when applied.

The tremolo unit draws 1mA, and may therefore necessitate an on-off switch for the StyloQIC if used.

The widely available 4093 quad NAND Schmitt i.c. was used but a 40106 hex Schmitt inverter may also be used to good effect, in which case the value of capacitor C1 needs to be halved.

Rev. Thomas Scarborough,
Fresnaye,
South Africa.

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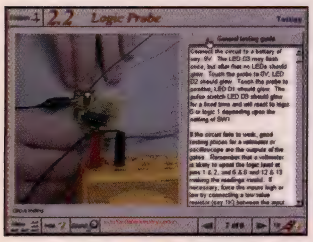
ELECTRONICS PROJECTS

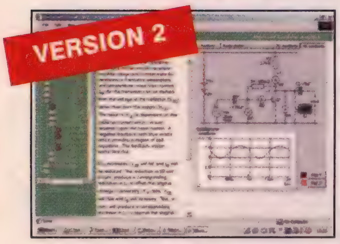


Logic Probe testing

Electronic Projects is split into two main sections: **Building Electronic Projects** contains comprehensive information about the components, tools and techniques used in developing projects from initial concept through to final circuit board production. Extensive use is made of video presentations showing soldering and construction techniques. The second section contains a set of ten projects for students to build, ranging from simple sensor circuits through to power amplifiers. A shareware version of Matrix's CADPACK **schematic capture**, **circuit simulation** and **p.c.b. design** software is included.
The projects on the CD-ROM are: Logic Probe; Light, Heat and Moisture Sensor; NE555 Timer; Egg Timer; Dice Machine; Bike Alarm; Stereo Mixer; Power Amplifier; Sound Activated Switch; Reaction Tester. Full parts lists, schematics and p.c.b. layouts are included on the CD-ROM.

ELECTRONIC CIRCUITS & COMPONENTS V2.0

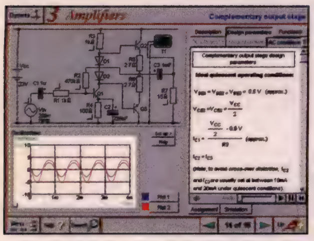
VERSION 2



Circuit simulation screen

Provides an introduction to the principles and application of the most common types of electronic components and shows how they are used to form complete circuits. The virtual laboratories, worked examples and pre-designed circuits allow students to learn, experiment and check their understanding. Version 2 has been considerably expanded in almost every area following a review of major syllabuses (GCSE, GNVQ, A level and HNC). It also contains both European and American circuit symbols. Sections include: ***Fundamentals:*** units & multiples, electricity, electric circuits, alternating circuits. ***Passive Components:*** resistors, capacitors, inductors, transformers. ***Semiconductors:*** diodes, transistors, op.amps, logic gates. ***Passive Circuits. Active Circuits.*** *The Parts Gallery* will help students to recognise common electronic components and their corresponding symbols in circuit diagrams. Included in the Institutional Versions are multiple choice questions, exam style questions, fault finding virtual laboratories and investigations/worksheets.

ANALOGUE ELECTRONICS

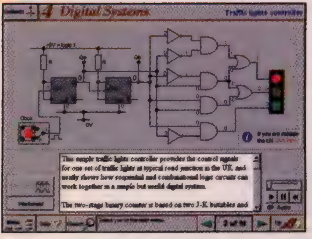


Complimentary output stage

Analogue Electronics is a complete learning resource for this most difficult branch of electronics. The CD-ROM includes a host of virtual laboratories, animations, diagrams, photographs and text as well as a SPICE electronic circuit simulator with over 50 pre-designed circuits.
Sections on the CD-ROM include: **Fundamentals** – Analogue Signals (5 sections), Transistors (4 sections), Waveshaping Circuits (6 sections). **Op.Amps** – 17 sections covering everything from Symbols and Signal Connections to Differentiators. **Amplifiers** – Single Stage Amplifiers (8 sections), Multi-stage Amplifiers (3 sections). **Filters** – Passive Filters (10 sections), Phase Shifting Networks (4 sections), Active Filters (6 sections). **Oscillators** – 6 sections from Positive Feedback to Crystal Oscillators. **Systems** – 12 sections from Audio Pre-Amplifiers to 8-Bit ADC plus a gallery showing representative p.c.b. photos.

DIGITAL ELECTRONICS V2.0

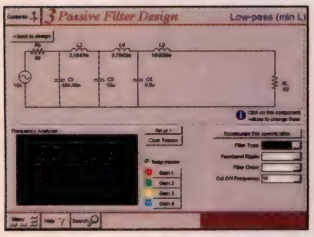
VERSION 2



Virtual laboratory – Traffic Lights

Digital Electronics builds on the knowledge of logic gates covered in *Electronic Circuits & Components* (opposite), and takes users through the subject of digital electronics up to the operation and architecture of microprocessors. The virtual laboratories allow users to operate many circuits on screen.
Covers binary and hexadecimal numbering systems, ASCII, basic logic gates, monostable action and circuits, and bistables – including JK and D-type flip-flops. Multiple gate circuits, equivalent logic functions and specialised logic functions. Introduces sequential logic including clocks and clock circuitry, counters, binary coded decimal and shift registers. A/D and D/A converters, traffic light controllers, memories and microprocessors – architecture, bus systems and their arithmetic logic units. Sections on Boolean Logic and Venn diagrams, displays and chip types have been expanded in Version 2 and new sections include shift registers, digital fault finding, programmable logic controllers, and microcontrollers and microprocessors. The Institutional versions now also include several types of assessment for supervisors, including worksheets, multiple choice tests, fault finding exercises and examination questions.

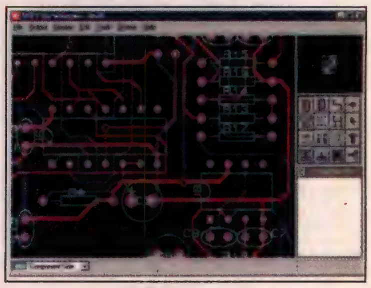
FILTERS



Filter synthesis

Filters is a complete course in designing active and passive filters that makes use of highly interactive virtual laboratories and simulations to explain how filters are designed. It is split into five chapters: **Revision** which provides underpinning knowledge required for those who need to design filters. **Filter Basics** which is a course in terminology and filter characterization, important classes of filter, filter order, filter impedance and impedance matching, and effects of different filter types. **Advanced Theory** which covers the use of filter tables, mathematics behind filter design, and an explanation of the design of active filters. **Passive Filter Design** which includes an expert system and filter synthesis tool for the design of low-pass, high-pass, band-pass, and band-stop Bessel, Butterworth and Chebyshev ladder filters. **Active Filter Design** which includes an expert system and filter synthesis tool for the design of low-pass, high-pass, band-pass, and band-stop Bessel, Butterworth and Chebyshev op.amp filters.

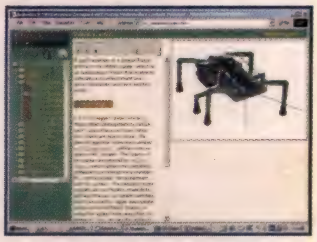
ELECTRONICS CAD PACK



PCB Layout

Electronics CADPACK allows users to design complex circuit schematics, to view circuit animations using a unique SPICE-based simulation tool, and to design printed circuit boards. CADPACK is made up of three separate software modules. (These are restricted versions of the full Labcenter software.) **ISIS Lite** which provides full schematic drawing features including full control of drawing appearance, automatic wire routing, and over 6,000 parts. **PROSPICE Lite** (integrated into ISIS Lite) which uses unique animation to show the operation of any circuit with mouse-operated switches, pots. etc. The animation is compiled using a full mixed mode SPICE simulator. **ARES Lite** PCB layout software allows professional quality PCBs to be designed and includes advanced features such as 16-layer boards, SMT components, and an autorouter operating on user generated Net Lists.

ROBOTICS & MECHATRONICS



Case study of the Milford Instruments Spider

Robotics and Mechatronics is designed to enable hobbyists/students with little previous experience of electronics to design and build electromechanical systems. The CD-ROM deals with all aspects of robotics from the control systems used, the transducers available, motors/actuators and the circuits to drive them. Case study material (including the NASA Mars Rover, the Milford Spider and the Furby) is used to show how practical robotic systems are designed. The result is a highly stimulating resource that will make learning, and building robotics and mechatronic systems easier. The Institutional versions have additional worksheets and multiple choice questions.

- Interactive Virtual Laboratories
- Little previous knowledge required
- Mathematics is kept to a minimum and all calculations are explained
- Clear circuit simulations

PRICES

Prices for each of the CD-ROMs above are:

(Order form on third page)

Hobbyist/Student	**£45 inc VAT**
Institutional (Schools/HE/FE/Industry)	**£99 *plus* VAT**
Institutional 10 user (Network Licence)	**£199 *plus* VAT**
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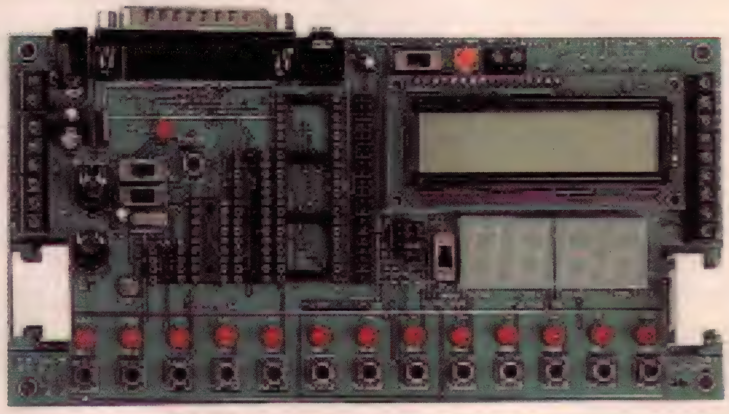


£145 including VAT and postage

12V 500mA plug-top PSU (UK plug) £7

25-way 'D' type connecting cable £5

SOFTWARE

Suitable for use with the Development Board shown above.

ASSEMBLY FOR PICmicro V2

(Formerly PICtutor)

Assembly for PICmicro microcontrollers V2.0 (previously known as PICtutor) by John Becker contains a complete course in programming the PIC16F84 PICmicro microcontroller from Arizona Microchip. It starts with fundamental concepts and extends up to complex programs including watchdog timers, interrupts and sleep modes. The CD makes use of the latest simulation techniques which provide a superb tool for learning: the Virtual PICmicro microcontroller. This is a simulation tool that allows users to write and execute MPASM assembler code for the PIC16F84 microcontroller on-screen. Using this you can actually see what happens inside the PICmicro MCU as each instruction is executed which enhances understanding.

● Comprehensive instruction through 39 tutorial sections ● Includes Vlab, a Virtual PICmicro microcontroller: a fully functioning simulator ● Tests, exercises and projects covering a wide range of PICmicro MCU applications ● Includes MPLAB assembler ● Visual representation of a PICmicro showing architecture and functions ● Expert system for code entry helps first time users ● Shows data flow and fetch execute cycle and has challenges (washing machine, lift, crossroads etc.) ● Imports MPASM files.

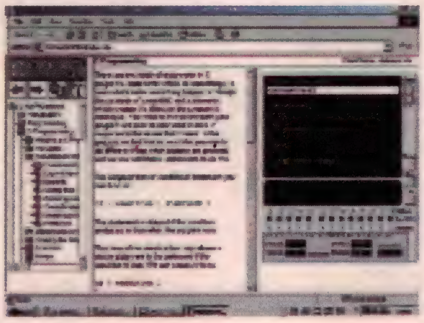
Virtual PICmicro

'C' FOR PICmicro VERSION 2

The C for PICmicro microcontrollers CD-ROM is designed for students and professionals who need to learn how to program embedded microcontrollers in C. The CD contains a course as well as all the software tools needed to create Hex code for a wide range of PICmicro devices – including a full C compiler for a wide range of PICmicro devices.

Although the course focuses on the use of the PICmicro microcontrollers, this CD-ROM will provide a good grounding in C programming for any microcontroller.

● Complete course in C as well as C programming for PICmicro microcontrollers ● Highly interactive course ● Virtual C PICmicro improves understanding ● Includes a C compiler for a wide range of PICmicro devices ● Includes full Integrated Development Environment ● Includes MPLAB software ● Compatible with most PICmicro programmers ● Includes a compiler for all the PICmicro devices.



Minimum system requirements for these items: Pentium PC running Windows 98, NT, 2000, ME, XP; CD-ROM drive; 64MB RAM; 10MB hard disk space.

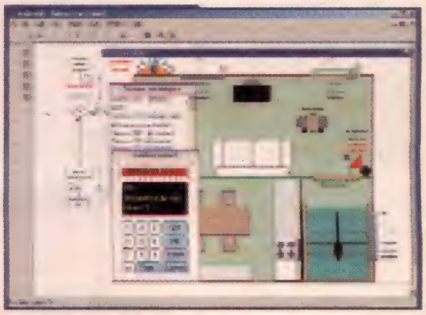
FLOWCODE FOR PICmicro

Flowcode is a very high level language programming system for PICmicro microcontrollers based on flowcharts. Flowcode allows you to design and simulate complex robotics and control systems in a matter of minutes.

Flowcode is a powerful language that uses macros to facilitate the control of complex devices like 7-segment displays, motor controllers and l.c.d. displays. The use of macros allows you to control these electronic devices without getting bogged down in understanding the programming involved.

Flowcode produces MPASM code which is compatible with virtually all PICmicro programmers. When used in conjunction with the Version 2 development board this provides a seamless solution that allows you to program chips in minutes.

● Requires no programming experience ● Allows complex PICmicro applications to be designed quickly ● Uses international standard flow chart symbols (ISO5807) ● Full on-screen simulation allows debugging and speeds up the development process ● Facilitates learning via a full suite of demonstration tutorials ● Produces ASM code for a range of 8, 18, 28 and 40-pin devices ● Institutional versions include virtual systems (burglar alarms, car parks etc.).



Burglar Alarm Simulation

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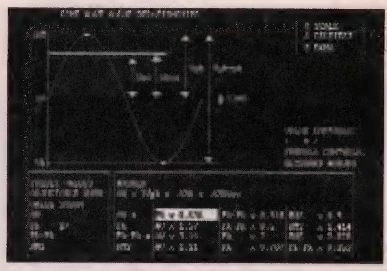

Sine wave relationship values

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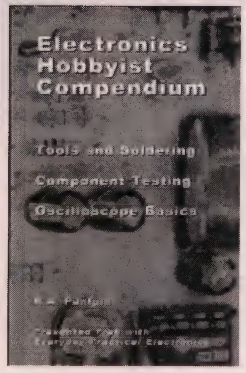
Electronics Hobbyist Compendium
Tools and Soldering
Component Testing
Oscilloscope Basics
R.A. Penfold
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EPE's own *Teach-In* CD-ROM, contains the full 12-part *Teach-In* series by John Becker in PDF form plus the *Teach-In* interactive software covering all aspects of the series. We have also added Alan Winstanley's highly acclaimed *Basic Soldering Guide* which is fully illustrated and which also includes *Desoldering.* The *Teach-In* series covers: Colour Codes and Resistors, Capacitors, Potentiometers, Sensor Resistors, Ohm's Law, Diodes and L.E.D.s, Waveforms, Frequency and Time, Logic Gates, Binary and Hex Logic, Op.amps, Comparators, Mixers, Audio and Sensor Amplifiers, Transistors, Transformers and Rectifiers, Voltage Regulation, Integration, Differentiation, 7-segment Displays, L.C.D.s, Digital-to-Analogue.

Each part has an associated practical section and the series includes a simple PC interface so you can use your PC as a basic oscilloscope with the various circuits.

A hands-on approach to electronics with numerous breadboard circuits to try out.

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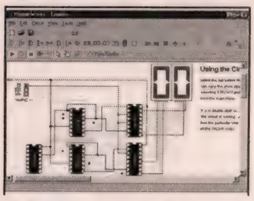
FREE WITH EACH TEACH-IN CD-ROM – *Electronics Hobbyist Compendium* 80-page book by Robert Penfold. Covers Tools For The Job; Component Testing; Oscilloscope Basics.

DIGITAL WORKS 3.0



Counter project

Digital Works Version 3.0 is a graphical design tool that enables you to construct digital logic circuits and analyze their behaviour. It is so simple to use that it will take you less than 10 minutes to make your first digital design. It is so powerful that you will never outgrow its capability • Software for simulating digital logic circuits • Create your own macros – highly scalable • Create your own circuits, components, and i.c.s • Easy-to-use digital interface • Animation brings circuits to life • Vast library of logic macros and 74 series i.c.s with data sheets • Powerful tool for designing and learning.

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MODULAR CIRCUIT DESIGN

VERSION 3

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Essential information for anyone undertaking GCSE or "A" level electronics or technology and for hobbyists who want to get to grips with project design. Over seventy different Input, Processor and Output modules are illustrated and fully described, together with detailed information on construction, fault finding and components, including circuit symbols, pinouts, power supplies, decoupling etc.

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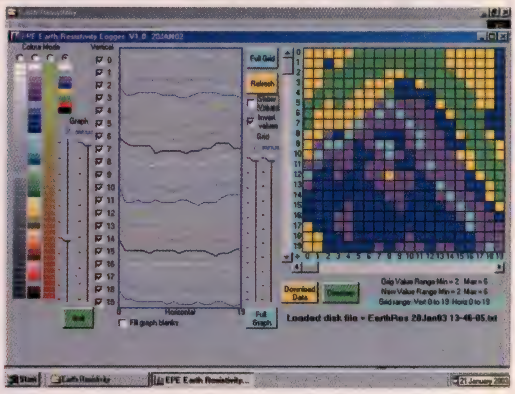
EARTH RESISTIVITY LOGGER



Grid Value Range Min = 2 Max = 6
New Value Range Min = 2 Max = 6
Grid range: Vert 0 to 19 Horiz 0 to 19

Loaded disk file = EarthRes 20Jan03 13-46-05.txt

JOHN BECKER

Part One

Help your local archaeological society to locate and reveal the hidden mysteries of our ancestors.

JANUARY and February 1997 saw the publication in *EPE* of Robert Beck's *Earth Resistivity Meter*, an electronic tool to assist amateur archaeological societies "see beneath the soil" in their search for ruins and other hidden features.

The design presented here is based upon the same concept as used in Robert's circuit, but it has been considerably simplified in terms of the components count and their ready-availability. Significantly, it has also been put under the command of a PIC microcontroller and provided with data logging facilities. The principal features of this design are outlined in Table 1.

DOWN TO EARTH

Before going any further, though, the author wishes to "put his cards on the survey grid". He is not an archaeologist and has approached this design purely as an electronic problem to be solved – transmit a signal, retrieve it at a distance and store it for later analysis.

Along the path to this end, he has researched a fair bit, chatted with a local archaeological society and with *EPE* readers who have knowledge in this field. Most importantly, Nick Tile, *EPE* reader and friend of the author, has spent several months successfully using the prototype for active archaeological survey work. More on this in Part 2. Further reference to Nick's surveying will be made during this article.

A list of useful references is quoted at the end of Part 2, to which readers are referred for more information on surveying techniques. The main reference source used by the author has been Anthony Clark's *Seeing Beneath the Soil.*

BASIC PRINCIPLES

For the sake of readers who have not yet been enticed into joining their local archaeological society in search of knowledge about our ancestors and how they lived, it is appropriate to outline how electronics can help us see subterranean features without ever touching a spade or trowel.

When two conductors are placed in moist soil with a d.c. voltage source connected across them, current will flow between them, just as it does through an ordinary resistor.

The amount of current that flows depends on how much resistance the soil interposes between the two electrodes. The value depends on several factors, the soil's water content and chemical make-up (i.e. the impurities the water contains), and the presence (or absence) of non-conductive objects. The relationship is complex, and will not be discussed in detail here, although some experiments which should give an insight into it are suggested in the text file supplied with the software. It is discussed more fully by Anthony Clark in his book.

The current flow through soil is also complicated by the fact that it is not flowing in a straight line, as it does (in effect) through an ordinary resistor. The current can simultaneously flow through a multitude of paths, not only horizontally, but three-dimensionally, as illustrated in Fig.1. It also radiates outwards beyond the main field, as you will see presently from Fig.2.

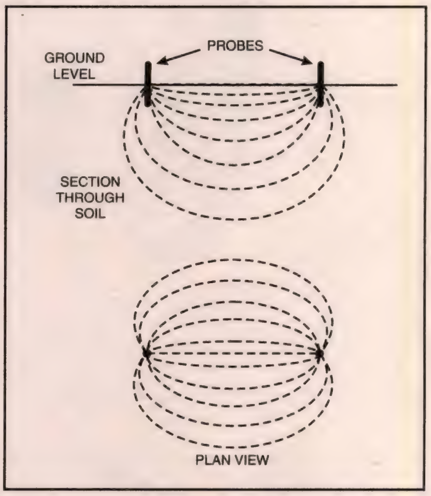
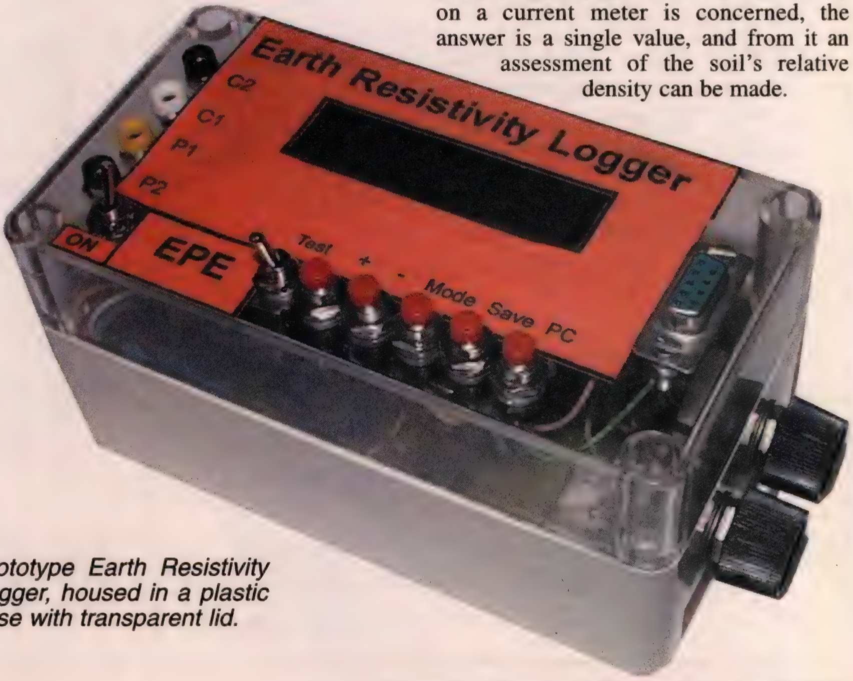


Fig.1. Current paths set up by probe array.

The overall current flow between the probes is thus not just governed by the resistance of one direct horizontal path, but by the total resistance of innumerable paths effectively in parallel within a given volume of soil, and each experiencing different values of resistance. Despite the complexity, though, as far as the reading on a current meter is concerned, the answer is a single value, and from it an assessment of the soil's relative density can be made.



Prototype Earth Resistivity Logger, housed in a plastic case with transparent lid.

What is being looked for in an electronic survey is reliably monitored variations in readings across a site, the pattern of which indicates where different sub-soil features exist.

UNIFORMITY PROBLEM

A problem arises, however, in that not only does the soil have resistance, but it also has capacitance and additionally exhibits various electrolysis effects as the d.c. current continues to flow, and most significantly, a polarization process takes place, resulting in progressively changing values on the meter.

To be able to take meaningful readings it is necessary to counteract the polarization effect. This can be done by passing an alternating current through the soil instead of a direct one. With each of the a.c. current's phases, the polarizing effects of the preceding phase are reversed, thus causing a more consistent current flow to occur in both directions.

Whilst the soil's electrolysis process will not be reversed, its effect is likely to be so minute in relation to the polarization effect, that it can be ignored during the relatively brief time during which current flow readings are taken.

The capacitance effects are also largely overcome by using an alternating current at a suitable frequency.

PROBING FREQUENCY

The question then arises: at what frequency should the current direction be repeatedly reversed? Too high a frequency will cause the soil's capacitance effects to "mop-up" and attenuate the alternating signal's amplitude. Too low a frequency will again cause variation in the monitored readings, albeit smaller than would occur through using a d.c. signal.

It appears that the optimum rate at which the signal phases must be changed has been established at around 137Hz (Anthony Clark quotes 137·5Hz but also says that 67Hz is used in some equipment). These frequencies assist in not only the elimination of the polarizing effects, but also in reducing the affect of other alternating electrical fields which might be present in the site being surveyed, such as a 50Hz mains frequency, for instance.

EPE contributor Aubrey Scoon has researched into this latter aspect and has reported the presence of many other frequencies in some locations he has examined, some emanating from a nearby "supercomputer" in one instance.

The frequencies of 67Hz and 137Hz (the latter is used in this Logger), are not a multiple of 50Hz, nor of the 60Hz mains cycle used in some countries, such as the USA. Thus, by performing rectification or sampling that is synchronised with the transmission signal, the effects of these extraneous fields can be reduced. They are also minimised by the use of a differential amplifier, which will be discussed presently.

It is worth pointing out, however, that in the suburban garden where the author's trials with this Logger were performed in conjunction with an oscilloscope, residual 50Hz mains currents were not evident.

MULTIPLE PROBES

The discussion so far has been in relation to the current flowing between two probes in series with a meter. Over the many years that geophysicists have been

TABLE 1. WHAT IT DOES

The PIC microcontroller performs the following functions:

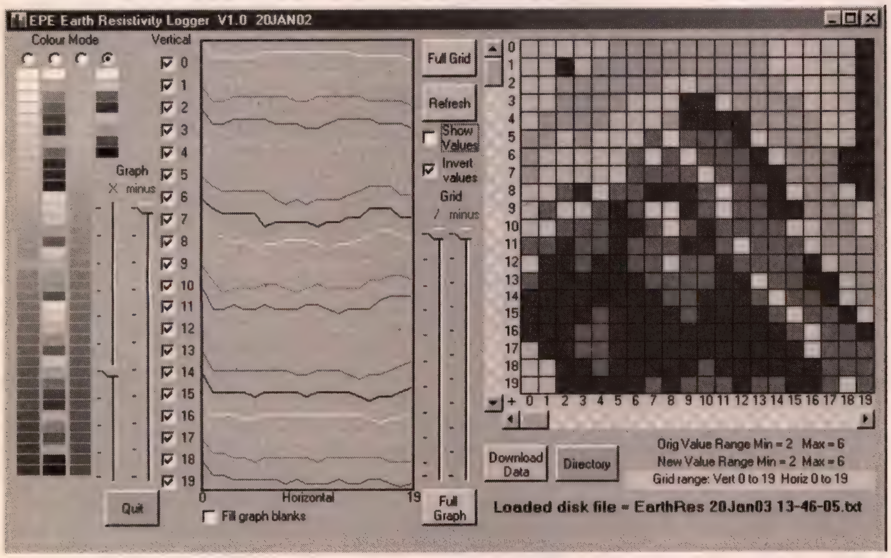
- Generates 137Hz square wave ground-penetrating transmission signal
- Converts the received and amplified analogue signal to a 10-bit digital value
- Stores each converted value to user-specified non-volatile (EEPROM) memory address representing specific site plotting coordinates
- Continually displays immediate real-time data and coordinates on alphanumeric liquid crystal display (l.c.d.)
- On request, outputs stored data via serial link to Windows 95/98/ME PC for storage to disk and subsequent analysis

Other features of the logger include:

- Switchable output resistance to vary transmission current
- Switchable amplifier gain, x1, x10, x100
- Pushswitch selection of survey site row and column coordinates allocation in memory
- Memory capacity for 16384 10-bit samples, representing a survey site grid of 128 x 128 squares
- Data storage action under complete user control
- Data locations may be overwritten with fresh data if required
- Sampled data stays in memory indefinitely, even after power switch-off
- Recall of last used survey coordinate when next switched on, allowing survey to be spread over several days or weeks
- Individually stepped push-button recall and display of recorded samples and their coordinates
- Total clearance of memory to zero value upon request, with security feature to help prevent erroneous use
- Operable from any d.c. supply between about 9V and 15V, consuming about 25mA. It is equally suited for use with a 9V PP9-size battery (rechargeable types are available), or a 12V car battery (see later)

Software features for the downloaded memory samples include:

- Program written in Visual Basic 6 (VB6)
- Disk storage under unique dated and timed file name
- Graphical display of data on PC screen as waveform graphs and value-related coloured or grey-scale grid squares
- Four screen slider controls allow data to be processed for best visual contrast to aid analysis
- Facility to invert data values for viewing as "valleys" or "peaks"
- Main screen display as 20 x 20 samples block, with vertical and horizontal panning across full 128 x 128 grid
- Secondary screen displays of separate grid or graph data for full 128 x 128 samples block
- Zoom facility for closer examination of separate graph and grid data
- Reloading of previous survey files via dedicated file selection screen
- Downloaded files stored in format suited for analysis and graphical display via Microsoft Excel (found on most PCs)
- Data may be downloaded to PC as often as required without disrupting its existing on-board storage (allowing on-going visual display of site progress across long periods)
- Suited to survey monitoring using any of the standard probing techniques (Wenner, Schlumberger, Twin-Probe, etc).


EPE Earth Resistivity Logger V1.0 20JAN02

Orig Value Range Min = 2 Max = 6
New Value Range Min = 2 Max = 6
Grid range: Vert 0 to 19 Horiz 0 to 19

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Typical example of one of the three analysis screens used by the Earth Resistivity Logger's PC software. The other two show full-screen displays of grid or graph data for a 128 x 128 samples survey site, with zoom facilities.

electrically probing the soil in their search for minerals and oil deposits (since 1946 says Robert Beck), it has been found that there are better probing techniques than just using two probes. Some of these have been adopted by archaeologists.

Most of the favoured ones all use four probes – two for transmission (TX), and two for reception (RX). The righthand section of Fig.2 shows one way in which the second pair of probes can be used. Anthony Clark says that there are also some techniques that use five probes – with push-pull TX across two and the fifth becoming a grounded reference perhaps?

TWIN PROBES

There are several ways in which four probes are used in relation to each other, and each with its own merits. Their use is outlined later, but no quality judgement is offered here on their appropriateness to various survey situations – but it is worth noting that Clark considers the Twin-Probe technique to be the most favoured for archaeological surveying, although the Wenner technique is said to provide more detailed results. Nick in his extensive use of the prototype adopted the Twin-Probe technique.

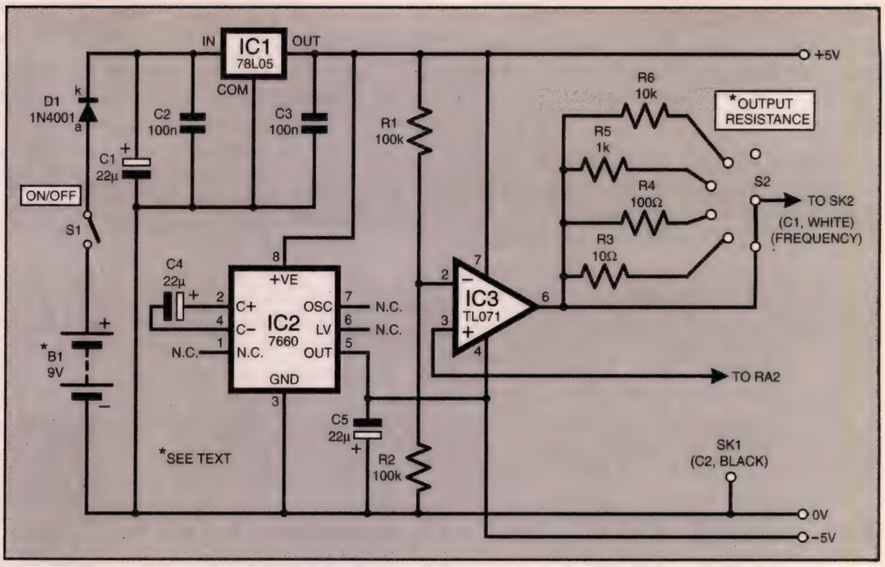


Fig.3. Power supply and transmission interface circuit for the Earth Resistivity Logger.

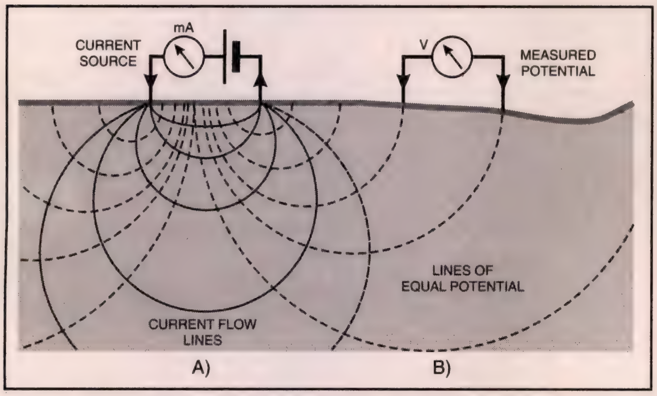


Fig.2. How current flowing between two probes is detected by a second pair.

The Twin-Probe and Wenner techniques were outlined in Robert Beck's article and were used in the author's garden tests with this Logger. They will be discussed in Part 2 in a bit more detail. Suffice to say for the moment, both involve placing in the soil a reference probe that is connected to the circuit's 0V line (common ground). This is regarded as one half of the TX probes pair.

To the other TX probe is fed the alternating voltage or current, evenly swinging as a square wave above and below the 0V reference value. The function of the TX probes is to set up a field of potential gradient in the soil, which is then sampled by the RX probes.

The RX probes are positioned at distances away from the TX probes as dictated by the probing technique being used. They are connected to the twin inputs of a differential amplifier, whose output signal amplitude is determined by the difference in the two input levels. It is this signal which is then monitored by the control circuit.

It is not even necessary to use special probes, any metal object that does not corrode and can be inserted into the soil with a wire attached will do. The probes don't even need to be inserted very far, just enough to penetrate the soil to make electrical contact with its moistness.

It will be obvious, of course, that dry soil will be less capable of passing a current than moist soil. Keep in mind that the surface of the soil can dry out faster than that below it, and so a reasonable amount of penetration should be allowed. Robert Beck allows 200mm with his probe structures discussed in Part 2.

With some sites it may be necessary to evenly damp the soil with water before adequate probing can begin.

POWER SUPPLY

The PIC-controlled processing circuit is almost irrelevant to the main aspects of soil monitoring! So first let's look at the power supply requirements, and the simple transmission circuit, both illustrated in Fig.3.

As said in Table 1, the power can originate from any d.c. source (e.g. battery) ranging between about 9V and 15V. This is input via diode D1 to the +5V voltage regulator IC1. The diode prevents distress to the circuit in the event of the battery being connected with the wrong polarity.

The regulated +5V output from IC1 powers the main PIC-controlled circuit, which must not receive a supply significantly greater than +5V. It also provides the positive power to the TX and RX circuits. Both of these circuits additionally need an equivalent negative supply. This is generated from the +5V line by the voltage inverting chip IC2, which outputs a voltage of close to –5V.

TRANSMISSION OUTPUT

Op.amp IC3 is the device which feeds the 137Hz alternating signal to one TX probe (the "active" TX probe). As previously said, the other TX probe is connected to the 0V power line. IC3 is configured as a comparator whose inverting input (pin 2) is tied to the potential divider chain formed by equal-value resistors R1 and R2. The resistors are connected across the +5V and 0V lines and the voltage at their junction is thus 2·5V.

The non-inverting input (pin 3) of IC3 is connected to one of the PIC microcontroller's output pins (RA2) and is fed with a 137Hz square wave, generated by the software, and which alternates between +5V and 0V. As this square wave repeatedly crosses above and below the 2·5V reference voltage, IC3's comparator action takes place and its output (pin 6) alternates between the device's upper and lower voltage limits, i.e. swinging between about +4V and –4V.

Note that the op.amp to which the TX probes are connected (IC3) is short-circuit protected internally and is unlikely to suffer if the probes accidentally come into contact with each other while the power is switched on. However, do not sustain such contact since it could cause regulator IC1 to get hot, and it will shorten the battery charge life.

OUTPUT RESISTANCE

Depending on the probing technique used, experienced geophysicists can determine not only the subterranean density, but also its possible composition. This is apparently achieved by pre-setting the current which flows between the two TX probes.

Robert discussed this in the '97 text, referring to the technique as providing a "constant current". It would appear, though, that his circuit did not provide a *constant* current in the literal sense – same current flowing irrespective of resistive conditions – but rather it provided a *current limit*. It is the same *limiting* approach that has been taken in this Logger design.

The output from IC3 can be switched by S2 to the active TX probe via one of five paths. These comprise a direct unlimited path, and four limiting paths via resistors R3 to R6, in order of 10Ω, 100Ω, 1kΩ and 10kΩ.

Readers are referred to the publications listed in Part 2 for information on resistive path use. The field tests performed by

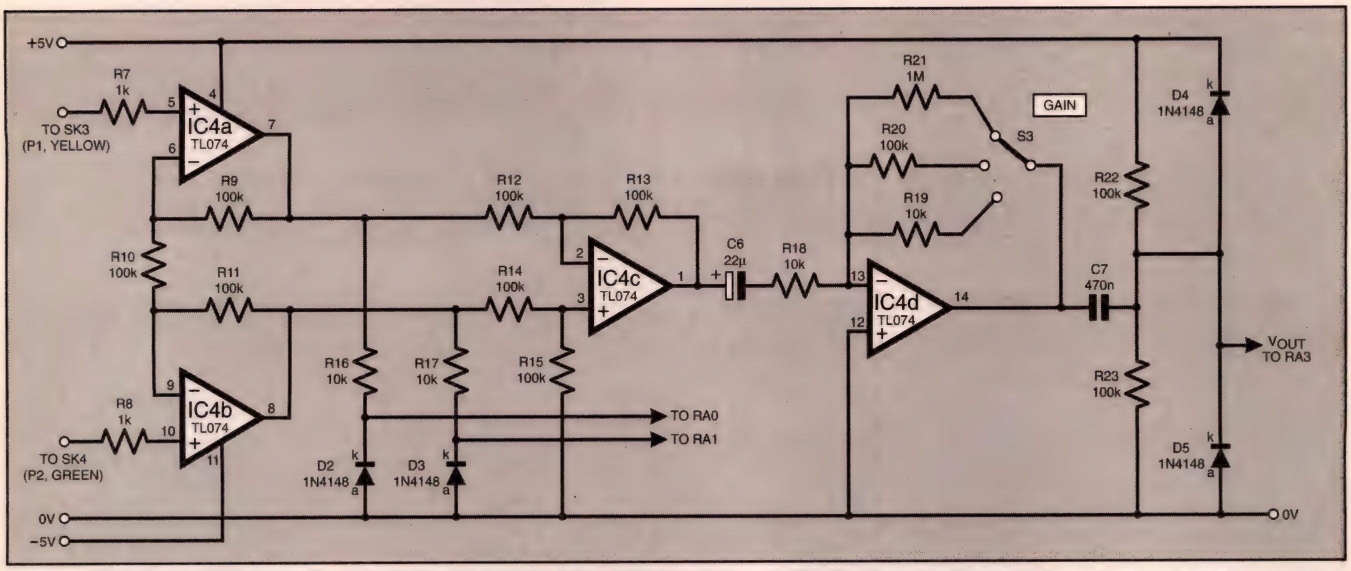


Fig.4. Differential amplifier that receives, amplifies and conditions the RX probes signal prior to sending to the ADC input of the PIC microcontroller.

the author and Nick Tile were carried out via the direct TX path (Nick says he has not found the switchable resistance facility to be useful). In this role, the signal amplitude across the TX probes is picked up by the RX probes simply as an alternating signal whose amplitude varies according to the soil density it has to pass through.

RECEIVING CIRCUIT

The receiving circuit is shown in Fig.4. The twin RX probes and their received d.c. coupled signals are connected via buffering resistors R7 and R8 to the respective inputs of the differential amplifier, formed initially around op.amps IC4a and IC4b and having a gain of three. The outputs from these op.amps are summed, still as d.c. signals, by op.amp IC4c, which provides unity gain.

The resulting signal represents the difference between the two input signal levels. It is now a.c. coupled via capacitor C6 to the amplifying stage around IC4d. Here the gain can be switched by S3 between ×1, ×10 and ×100. In the prototype's garden tests, the ×1 gain was satisfactory across the maximum probe separation distance that the dense garden flower beds would allow (11 metres)! Nick says he prefers the ×10 setting.

At this stage the signal is swinging above and below 0V. It has to be shifted so that it only swings between 0V and +5V at the maximum extremes, to suit the PIC microcontroller's limits. This is achieved by a.c. coupling the signal via capacitor C7 to the level-shifting potential divider formed by resistors R22 and R23. Diodes D4 and D5 limit the maximum voltage swing then fed to the PIC, preventing it from swinging above or below the PIC's limits of acceptance.

It will be seen that two additional signal paths are provided from the output of IC4a/b and consist of resistors R16 and R17 plus diodes D2 and D3. These are not part of the required analogue processing circuit but were included for use during software development. Their function will be described presently.

CONTROLLER CIRCUIT

The PIC-controlled processing circuit is shown in Fig.5. At its heart is a PIC16F876 microcontroller, IC5, manufactured by Microchip. It is run at 3·6864MHz, as set by crystal X1. The frequency may seem unusual, but crystals tuned to it are standard products. Its choice provides greater accuracy of the baud rate at which the logged data is output to the computer.

The software-generated 137Hz square wave pulse train is output via pin RA2, and fed to the TX op.amp IC3 in Fig.3.

Pin RA3 is the pin to which the level-shifted signal output from IC4d is input. The pin is configured by the software as an analogue-to-digital converter (ADC).

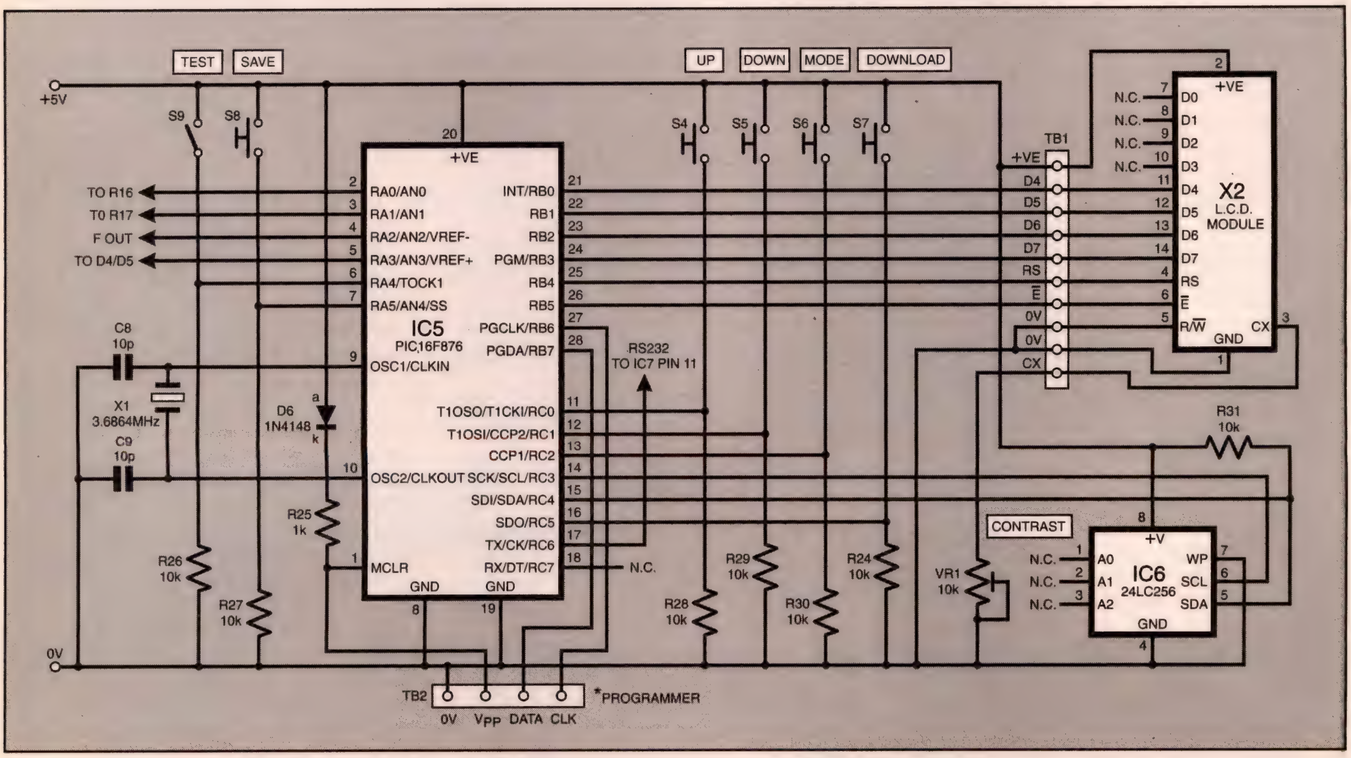


Fig.5. PIC-controlled processing, display and data storage circuit.

The PIC repeatedly converts the input signal to a 10-bit binary value which it outputs for display on the 2-line × 16-character l.c.d. X2, as a decimal number. As usual with the author's designs, the l.c.d. is controlled in 4-bit mode (and its pinouts on the printed circuit board are in his standard order). Its screen contrast is adjustable by preset VR1.

Pressing switch S8 causes the PIC to store (Save) the ADC's 10-bit binary output value to the 32 kilobyte (32768 bytes) serial EEPROM chip, IC6, at the address set by the user via switches S4 to S6. This chip is another Microchip device, and was first demonstrated by the author in his *PIC16F87x Data Logger* of Aug/Sep '99. Its device number, 24LC256, indicates that it has 256K single-bit memory locations. These are accessed as 8-bit bytes.

In other applications, the 24LC256 is capable of being multiplexed with seven others of its type, using its A0 to A2 inputs to set each device's multiplexed address. In this application they are left unconnected, leaving them biased internally. Resistor R31 is essential to the correct reading of the device's retrieved data output value.

The 24LC256 data sheet can be downloaded from Microchip's web site (**www.microchip.com**).

Data stored in the 24LC256 can be retrieved and downloaded serially to a PC via the RS-232 interface device (IC7) and socket SK5, in Fig.6. Transfer is initiated by pressing switch S7. Once started, all 32K bytes are sent to the PC in consecutive address order.

DATA SAMPLING

The software controls the output of a train of square wave pulses at the 137Hz rate. Data sampling takes place on each phase of the output pulse (high and low). On each complete cycle, the minimum value received is subtracted from the maximum (to establish the received signal's amplitude) and the result stored to a 32-byte temporary memory block. So that maximum peak-to-peak values of the received square wave have stabilised, the synchronous sampling takes place at the end of each peak.

About once a second, the pulse train stops while the 32 sample values are averaged, and the l.c.d. display updated. The pulse train then recommences for another second. This gives the soil time to respond to the re-application of the a.c. waveform, and for the effects of any d.c. currents to be over-ridden.

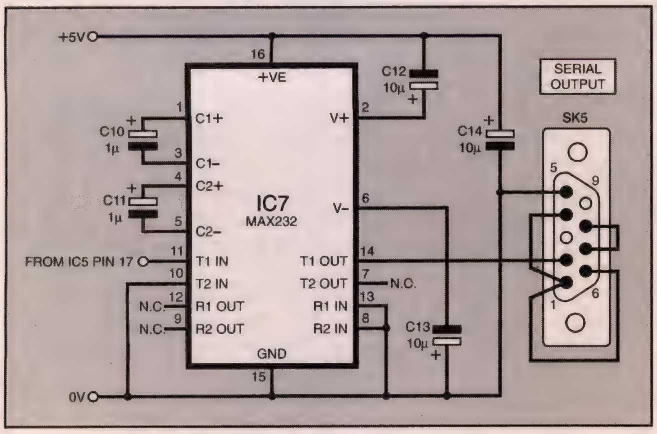


Fig.6. RS-232 interface circuit.

COMPONENTS

Approx. Cost Guidance Only **£45** excl. batts & case

See SHOP TALK page

Resistors

R1, R2, R9 to R15, R20, R22, R23	100k (12 off)
R3	10Ω
R4	100Ω
R5, R7, R8, R25	1k (4 off)
R6, R16 to R19, R24, R26 to R31	10k (12 off)
R21	1M

All 0·25W 5% carbon film or better

Potentiometer

VR1	10k min. preset, round

Capacitors

C1, C4 to C6	22µ radial elect. 25V (4 off)
C2, C3	100n ceramic, 5mm pitch (2 off)
C7	470n ceramic, 5mm pitch
C8, C9	10p ceramic, 5mm pitch (2 off)
C10, C11	1µ radial elect. 16V (2 off)
C12 to C14	10µ radial elect 16V (3 off)

Semiconductors

D1	1N4001 rectifier diode
D2 to D6	1N4148 signal diode (5 off)
IC1	78L05 +5V 100mA voltage regulator
IC2	ICL7660 voltage inverter
IC3	TL071 f.e.t. op.amp
IC4	TL074 quad f.e.t. op.amp
IC5	PIC16F876 microcontroller, preprogrammed (see text)
IC6	24LC256 256 kilobit serial EEPROM
IC7	MAX232 RS-232 interface driver

Miscellaneous

S1, S9	s.p.s.t. min. toggle switch (2 off)
S2	2-pole 6-way rotary switch
S3	4-pole 3-way rotary switch
S4 to S8	min. push-to-make switch (5 off)
SK1 to SK4	4mm single-socket, 1 each black, white, yellow, green (see text)
SK5	9-pin D-type serial connector, female, chassis mounting
TB1, TB2	pin-header strips to suit, or 1mm terminal pins (2 off)
X1	3·2768MHz crystal
X2	2-line, 16-character (per line) alphanumeric l.c.d. module

Printed circuit board, available from the *EPE PCB Service*, code 388; plastic case with see-through lid, 190mm x 110mm x 90mm (see text); 8-pin d.i.l. socket (3 off); 14-pin d.i.l. socket; 28-pin d.i.l. socket; knobs (2 off); 4mm plugs, colours to match 4mm sockets (4 off); heavy-duty crocodile clips, with coloured covers to match 4mm sockets (4 off); robust cable for probes (see text); 9V PP3 battery and clip (see text); p.c.b. supports (4 off); nuts and bolts to suit l.c.d. mounting style (4 off each); internal connecting wire; solder, etc.

TEST VALUE DISPLAY

Resistors R16 and R17, mentioned previously, allow the PIC to monitor the voltage on the outputs of IC4a/IC4b for test purposes, via its ADC inputs RA0/RA1. Diodes D2 and D3 prevent the PIC from receiving damaging negative voltages.

Originally, these outputs were intended purely for development use. However, their use has also proved beneficial in the outdoor monitoring environment and has been retained. The monitored values are displayed in decimal on the l.c.d. and provide indication of relative probe signal strengths, and of the loss of connection to one or more probes.

In relation to this test-motivated option, a second signal strength display option has been included via the software. The second mode displays the upper and lower peak values of the signal applied to the PIC's RA3 input. The two modes are selected by toggle switch S9.

SOFTWARE

In common with many other PIC designs, the facility has been provided to program the PIC *in situ*, via connector TB2. Diode D6 and resistor R25 prevent distress to the +5V line during programming.

Software, including source code files, for the PIC unit and PC interface is available on 3·5-inch disk from the Editorial office (a small handling charge applies – see *EPE PCB Service* page) or it can be downloaded free from the *EPE* FTP site. The latter is accessible via the top of the home page of the main *EPE* web site at **www.epemag.wimborne.co.uk**. Click on "FTP Site (downloads)", then in turn on PUB and PICS, in which page the files are in the folder named **EarthRes**.

This month's *ShopTalk* page provides information about obtaining pre-programmed PICs.

The PIC program (ASM) was written in TASM, although the run-time assembly is supplied as an MPASM HEX file, which has configuration values embedded in it (crystal XT, WDT off, POR on, all other values off).

Regarding the PC interface, if you have Visual Basic 6 already installed on your machine, you only need to use files **EarthRes.exe** and **INPOUT.DLL**. Copy them into a new folder named **C:\EARTH RES**, or any other of your choosing on Drive C (the usual hard drive letter).

The ability to install to another drive letter, e.g. Drive E on a partitioned drive, has not been provided with this program. Although the author has previously offered the option with other VB6 programs, feedback from readers has indicated that the option is not always reliable with some systems. Consequently, it has been dropped from this program. Readers who know how this option can be reliably implemented with VB6 are invited to tell the author at *EPE*!

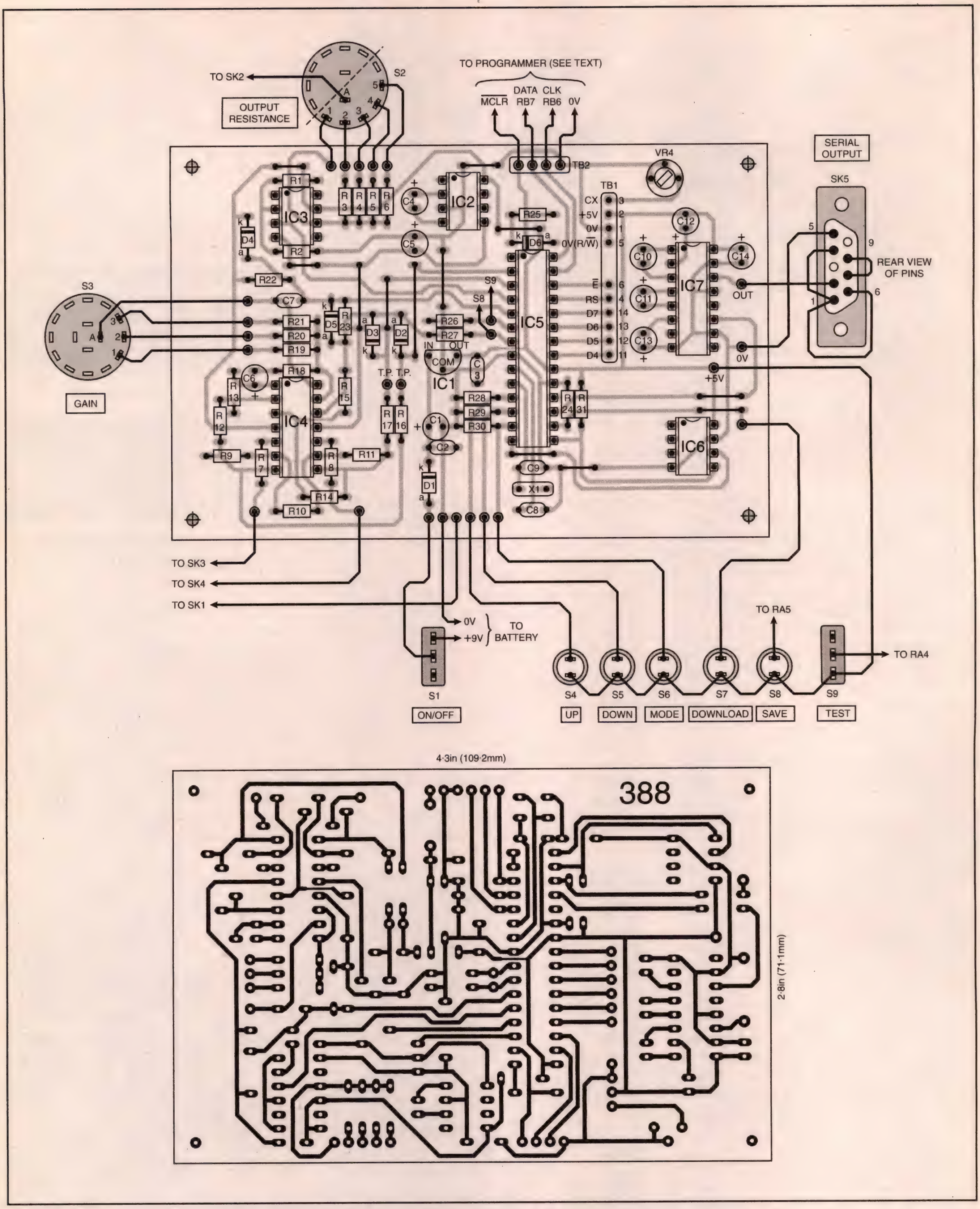


Fig.7. Printed circuit board component layout and full-size copper foil master track pattern for the Earth Resistivity Logger.

If you do not have VB6, you need three other files, **comdlg32.ocx**, **Mscomctl.ocx** and **Msvbm60.dll**, held on our 3.5-inch disk named Interface Disk 1, and in the Interface folder on the FTP site (they are also included with the *Toolkit TK3* software). These files must be copied into the same folder as the other Earth Resistivity files.

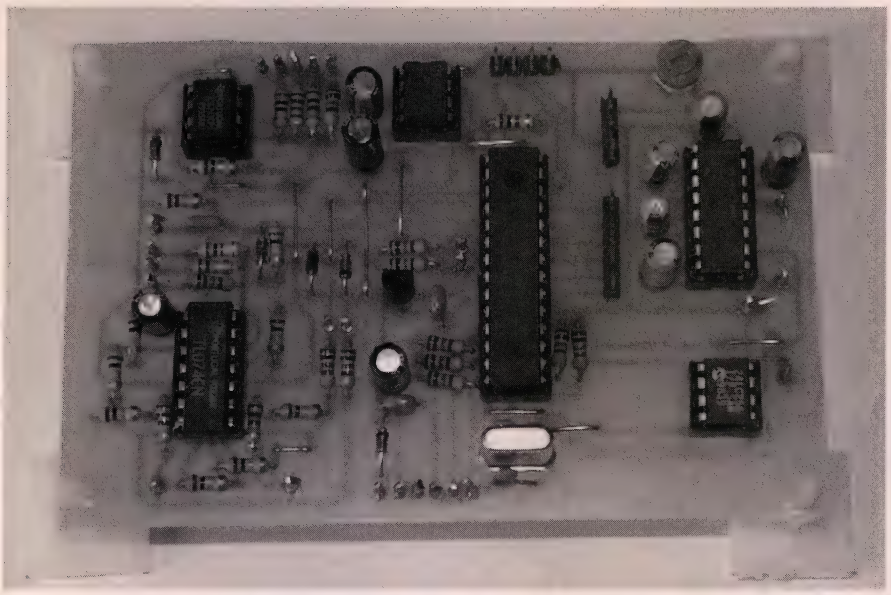
CONSTRUCTION

Details of the component and track layouts for the printed circuit board (p.c.b.) are shown in Fig.7. This board is available from the *EPE PCB Service*, code 388.

Assemble in any preferred order, ensuring that all the on-board link wires are included, and that all polarity-conscious components are the correct way round. The use of sockets for all the dual-in-line (d.i.l.) i.c.s is recommended; it is *essential* to use one for the PIC, IC5. Treat all i.c.s as static sensitive and discharge static electricity from yourself before handling them, by touching the bare grounded metal of an item of earthed equipment, for example.

Double-check the perfection of your soldering and component positioning before applying power. Do not insert any of the d.i.l. i.c.s until the correctness of the +5V output from regulator IC1 has been proved.

To provide a degree of waterproofness, the prototype was mounted in a robust plastic box with a see-through lid. The l.c.d. was mounted below the lid on the inside. If a *metal* box with a see-through lid can be found, it would provide even greater durability.



The final prototype board prior to installation.

It is recommended that a case of at least 50 per cent larger than used in the prototype should be employed to allow a large 9V to 12V battery to be adequately housed.

Probe sockets were 2mm types on the prototype, simply because the author had them in stock. It is recommended that 4mm types should be used. These provide greater robustness of the plugged connections and allow them to be removed readily. Nick recommends the use of restraints near the sockets to prevent the connections pulling out during a survey.

The probe sockets should be colour coded, as should their respective plugs. Colour suggestions are shown in the circuit diagrams of Fig.3 and Fig.4, but may be changed to suit availability. It is important NOT to duplicate the colours – doing so could result in leads being incorrectly allocated to probes.

The use of crocodile clips with colour-coded plastic covers was found to facilitate the connection of leads to the probes themselves. Heavy-duty crocodile clips are recommended for ease of use (especially in cooler or wet weather!).

When testing the prototype, it did not appear to matter whether the probe leads were screened or not. Consequently, standard lighting or low current cable could be used. Twin-core mains cable was used by the author and Nick, but in long term surveys it might prove more convenient to have a mix of cable arrangements, of differing lengths and cores. Obviously the thicker it is, the lower the loss over long lengths, but 50m (say) of such cable is expensive, and heavy to drag about.

Details of constructing customised probes are given in Part 2, but in simple applications four thin metal rods of the type used in gardens as flower supports can be used.

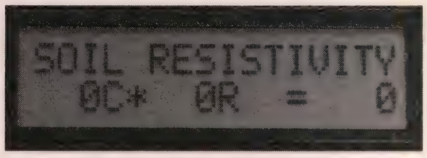
TESTING

Having established that +5V is present on the output of regulator IC1, plug in the voltage inverter chip, IC6, and check that around –5V is present on its output. Naturally, always disconnect power before making component changes.

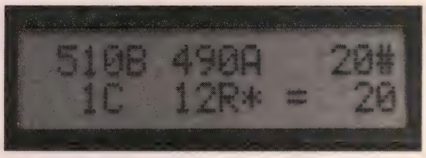
If all is well, the remaining i.c.s can be inserted and the l.c.d. connected. Typical pinouts for the latter are shown in Fig.8. It will probably be necessary to adjust its contrast using VR1 before a display will be seen.

With power switched on again, check that +5V and –5V are still present where they should be. Switch off immediately if they are not, and correct the cause of malfunction.

On line 1 of the l.c.d., the message "SOIL RESISTIVITY" will be displayed briefly before being replaced by some numerical values, with more on line 2.



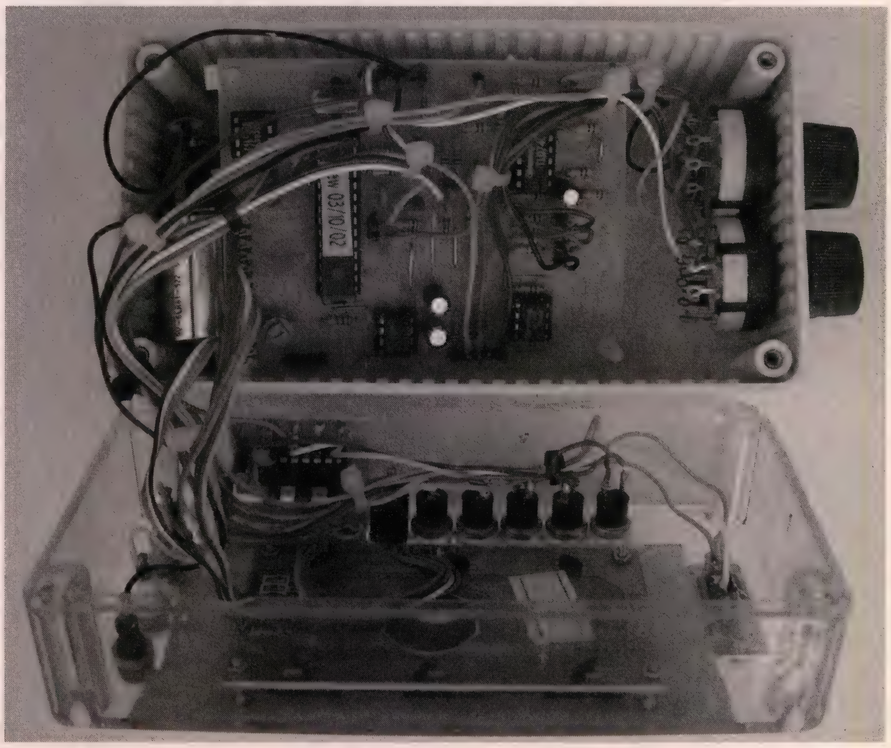
L.C.D. display following switch-on.



Example display when carrying out soil monitoring with S9 switched on to test mode.

With Test switch S9 switched on, the first two values on line 1 show the monitored values present at the outputs of IC4a/IC4b, as detected by the PIC's ADC conversions. Respectively, they are suffixed by the letters B and A, indicating the op.amp to which they refer (as given in the circuit diagram Fig.4).

With S9 off, the values are the upper and lower peak values resulting from the ADC conversion of the output of IC4d. They are suffixed by the letters H and L (High and Low). Any value between 0 and 1023 could appear at this time for all four readings.



Interior of the case showing the relative positioning of the components. The p.c.b. is the first prototype which did not include the RS-232 device, IC7. The latter can be seen on its own sub-board to the left of the push-switches. It is recommended that a larger case is used to allow a heavier-duty battery to be inserted.

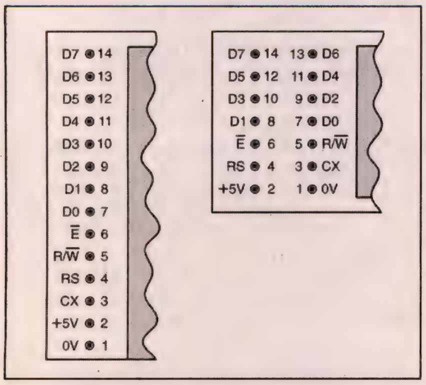


Fig.8. The two "standard" l.c.d. module pinout arrangements.

At the top right of line 1 is another number, suffixed by a hash symbol (#). This is the processed value that, when Save switch S8 is pressed, is stored to the serial memory as a grid value for the coordinates on line 2. Switching between gain settings using S3, the value will change. (During a survey always keep S3 at the same setting.)

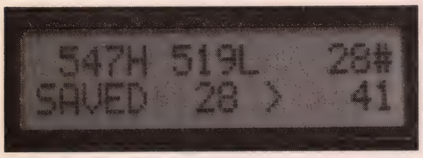
Note that if too strong an input signal is amplified, the op.amp's output may saturate (reach its maximum obtainable level). In practice, keep the value at the right of line 1 well below about 500. A value of 1023 is the maximum that can result from an ADC conversion, indicating that the ADC has received an input voltage equal to the power line voltage of +5V. This is an improbable event as the op.amp output is unlikely to swing that high.

L.C.D. LINE 2

At the left of line 2 are shown the column and row values which represent the survey grid coordinates, and thus the location in the serial memory at which the processed IC4 value is stored. They are suffixed C and R respectively. An asterisk symbol (*) will be seen to the right of one or the other of these coordinate values (more on setting coordinates in a moment).

At the right of line 2 is shown the value that is currently stored at the specified memory address. During the survey it will normally show 0 as each new coordinate is selected. When the Save switch S8 is pressed the display will change to repeat the number that has just been saved to the memory as a 2-byte value. At any time during the survey, the coordinate switches may be used to recall the values that are stored for each grid location.

There are three switches for coordinate setting. Two of them, S4 and S5, respectively increment or decrement the value beside which is shown the asterisk. The range is 0 to 127, rolling over to 0 after incrementing beyond 127, or rolling over to 127 after decrementing below 0.



```
547H 519L    28#
SAVED   28 >   41
```

Example of display when Save switch S8 is pressed. In this case saving 28 to EEPROM location 41.

Pressing Mode switch S6 changes the position of the asterisk, thus allocating the +/– switches to that aspect of the grid, i.e. vertical (column) or horizontal (row).

DATA TRANSFER SWITCH

Pressing Download switch S7 causes the PIC to send the contents of the serial memory to the PC at a rate of 9600 baud. As previously said, the values for each of the 16384 possible grid coordinates are stored as two bytes – the MSB and LSB of the 10-bit ADC values.

No attempt has been made to be selective about which set of values is sent to the PC. All 32768 values are sent on each occasion that S7 is pressed. The transfer takes about 30 seconds.

During transfer, the top l.c.d. line shows the message "SENDING TO PC", with line 2 blank. Upon completion of the transfer, line 2 shows "SENDING FINISHED", and line 1 briefly displays the "SOIL RESISTIVITY" message again, before clearing to once more show the values being sampled.

Line 2 remains with its last message shown until the asterisk (Mode) switch S6 is again pressed, to once more show the coordinate values.

```
SENDING TO PC
SENDING FINISHED
```

Example display when downloading stored data to a PC-compatible computer has been completed.

Check that all the switches perform as intended. It is not necessary to have probes connected at this time, and it does not matter that the serial download will not be destined anywhere – the PC's data reception side of things will be covered in Part 2.

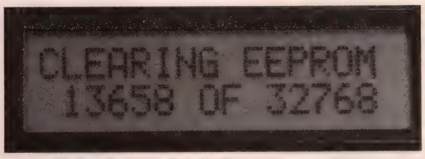
PROGRAMMED ASIDE

Incidentally, experiments were made using a graphics l.c.d. instead of an alphanumeric one, to see if survey data could be illustrated by the unit as an inbuilt 20 × 20 grid display. However, the ability to display values as different intensity grey-scales was found to be too limited to justify the extra expense (at least another £30) and so the facility was dropped.

Had the result been acceptable, a PIC16F877 would have been used with the screen, in a manner similar to the author's *Using Graphics L.C.D.s with PICs* article of Jan '01.

EEPROM RESETTING

The contents of the serial EEPROM can be reset to zero when required. As a security measure (to avoid resetting inappropriately!), the reset routine can only be called at the moment that the power is being switched on. With the power off, press and hold down Save switch S8, then switch on the power. When the message CLEARING EEPROM is seen, release S8.



```
CLEARING EEPROM
 13658 OF 32768
```

Example display during serial memory resetting.

On line 2 will be a progress count display as the software writes zeros to all 32768 EEPROM data locations. It is a somewhat lengthy process, taking about three and half minutes. This is due to numerous essential delays that are built into the writing procedure.

The software for the EEPROM writing and reading was originally downloaded from Microchip's CD-ROM for use in the *PIC16F877 Data Logger* referred to earlier. It is recommended that you do not attempt to modify Microchip's coding to speed the resetting process!

On completion of the resetting, which also resets the column and row values, the screen briefly shows the SOIL RESISTIVITY message and proceeds in the normal way as described earlier.

NEXT MONTH

In the final part next month, the PC-compatible Windows software is described and probing methods discussed.

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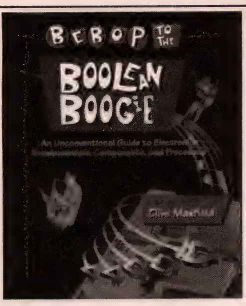

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S. W. Amos and Roger Amos

Scroggie's Foundations is a classic text for anyone working with electronics, who needs to know the art and craft of the subject. It covers both the theory and practical aspects of a huge range of topics from valve and tube technology, and the application of cathode ray tubes to radar, to digital tape systems and optical recording techniques.

Since *Foundations of Wireless* was first published over 60 years ago, it has helped many thousands of readers to become familiar with the principles of radio and electronics. The original author Sowerby was succeeded by Scroggie in the 1940s, whose name became synonymous with this classic primer for practitioners and students alike. Stan Amos, one of the fathers of modern electronics and the author of many well-known books in the area, took over the revision of this book in the 1980s and it is he, with his son, who have produced this latest version.

400 pages **Order code NE27** **£21.99**

GETTING THE MOST FROM YOUR MULTIMETER
R. A. Penfold

This book is primarily aimed at beginners and those of limited experience of electronics. Chapter 1 covers the basics of analogue and digital multimeters, discussing the relative merits and the limitations of the two types. In Chapter 2 various methods of component checking are described, including tests for transistors, thyristors, resistors, capacitors and diodes. Circuit testing is covered in Chapter 3, with subjects such as voltage, current and continuity checks being discussed.

In the main little or no previous knowledge or experience is assumed. Using these simple component and circuit testing techniques the reader should be able to confidently tackle servicing of most electronic projects.

96 pages **Order code BP239** **£4.49**

DIGITAL GATES AND FLIP-FLOPS
Ian R. Sinclair

This book, intended for enthusiasts, students and technicians, seeks to establish a firm foundation in digital electronics by treating the topics of gates and flip-flops thoroughly and from the beginning.

Topics such as Boolean algebra and Karnaugh mapping are explained, demonstrated and used extensively, and more attention is paid to the subject of synchronous counters than to the simple but less important ripple counters.

No background other than a basic knowledge of electronics is assumed, and the more theoretical topics are explained from the beginning, as also are many working practices. The book concludes with an explanation of microprocessor techniques as applied to digital logic.

200 pages **Order code PC106** **£9.95**

Music, Audio and Video

QUICK GUIDE TO ANALOGUE SYNTHESIS
Ian Waugh

Even though music production has moved into the digital domain, modern synthesisers invariably use analogue synthesis techniques. The reason is simple – analogue synthesis is flexible and versatile, and it's relatively easy for us to understand. The basics are the same for all analogue synths, and you'll quickly be able to adapt the principles to any instrument, to edit existing sounds and create exciting new ones. This book describes: How analogue synthesis works; The essential modules every synthesiser has; The three steps to synthesis; How to create phat bass sounds; How to generate filter sweeps; Advanced synth modules; How to create simple and complex synth patches; Where to find soft synths on the Web.

If you want to take your synthesiser – of the hardware or software variety – past the presets, and program your own sounds and effects, this practical and well-illustrated book tells you what you need to know.

60 pages **Order code PC118** **£7.45**

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Ian Waugh

MP3 files, the latest digital music format, have taken the music industry by storm. What are they? Where do you get them? How do you use them? Why have they thrown record companies into a panic? Will they make music easier to buy? And cheaper? Is this the future of music?

All these questions and more are answered in this concise and practical book which explains everything you need to know about MP3s in a simple and easy-to-understand manner. It explains:

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Whether you want to stay bang up to date with the latest music or create your own MP3s and join the on-line digital music revolution, this book will show you how.

60 pages **Order code PC119** **£7.45**

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ELECTRONIC MUSIC AND MIDI PROJECTS
R. A. Penfold

Whether you wish to save money, boldly go where no musician has gone before, rekindle the pioneering spirit, or simply have fun building some electronic music gadgets, the designs featured in this book should suit your needs. The projects are all easy to build, and some are so simple that even complete beginners at electronic project construction can tackle them with ease. Stripboard layouts are provided for every project, together with a wiring diagram. The mechanical side of construction has largely been left to individual constructors to sort out, simply because the vast majority of project builders prefer to do their own thing in this respect.

None of the designs requires the use of any test equipment in order to get them set up properly. Where any setting up is required, the procedures are very straightforward, and they are described in detail.

Projects covered: Simple MIIDI tester, Message grabber, Byte grabber, THRU box, MIDI auto switcher, Auto/manual switcher, Manual switcher, MIDI patchbay, MIDI controlled switcher, MIDI lead tester, Program change pedal, Improved program change pedal, Basic mixer, Stereo mixer, Electronic swell pedal, Metronome, Analogue echo unit.

124 pages **Order code PC116** **£10.95**

THE INVENTOR OF STEREO – THE LIFE AND WORKS OF ALAN DOWER BLUMLEIN
Robert Charles Alexander

This book is the definitive study of the life and works of one of Britain's most important inventors who, due to a cruel set of circumstances, has all but been overlooked by history.

Alan Dower Blumlein led an extraordinary life in which his inventive output rate easily surpassed that of Edison, but whose early death during the darkest days of World War Two led to a shroud of secrecy which has covered his life and achievements ever since.

His 1931 Patent for a Binaural Recording System was so revolutionary that most of his contemporaries regarded it as more than 20 years ahead of its time. Even years after his death, the full magnitude of his detail had not been fully utilized. Among his 128 patents are the principal electronic circuits critical to the development of the world's first elecronic television system. During his short working life, Blumlein produced patent after patent breaking entirely new ground in electronic and audio engineering.

During the Second World War, Alan Blumlein was deeply engaged in the very secret work of radar development and contributed enormously to the system eventually to become 'H2S' – blind-bombing radar. Tragically, during an experimental H2S flight in June 1942, the Halifax bomber in which Blumlein and several colleagues were flying, crashed and all aboard were killed. He was just days short of his thirty-ninth birthday.

420 pages **Order code NE32** **£16.99**

VIDEO PROJECTS FOR THE ELECTRONICS CONSTRUCTOR
R. A. Penfold

Written by highly respected author R. A. Penfold, this book contains a collection of electronic projects specially designed for video enthusiasts. All the projects can be simply constructed, and most are suitable for the newcomer to project construction, as they are assembled on stripboard.

There are faders, wipers and effects units which will add sparkle and originality to your video recordings, an audio mixer and noise reducer to enhance your soundtracks and a basic computer control interface. Also, there's a useful selection on basic video production techniques to get you started.

Complete with explanations of how the circuit works, shopping lists of components, advice on construction, and guidance on setting up and using the projects, this invaluable book will save you a small fortune.

Circuits include: video enhancer, improved video enhancer, video fader, horizontal wiper, improved video wiper, negative video unit, fade to grey unit, black and white keyer, vertical wiper, audio mixer, stereo headphone amplifier, dynamic noise reducer, automatic fader, pushbutton fader, computer control interface, 12 volt mains power supply.

124 pages **Order code PC115** **£10.95**

PC MUSIC – THE EASY GUIDE
Robin Vincent

How do I make music on my PC? Can I record music onto my PC? What's a sequencer? How can I get my PC to print a music score? What sort of a soundcard do I need? What hardware and software do I need? How do I connect a keyboard to my PC?:

Just a few of the questions you've probably asked. Well, you'll find the answers to all these questions, and many more, in this book. It will show you what can be done, what it all means, and what you will need to start creating your own music on your PC. It's an easy read, it's fully illustrated and it will help you understand how a computer can be used as a creative music tool.

It covers soundcards, sequencers, hard disk digital audio recording and editing, plug-ins, printing scores with notation software, using your PC as a synthesiser, getting music onto and off the Internet, using Windows, sample PC music setups, FAQs, a glossary, advice on hardware and software, and a list of industry contacts.

116 pages **Order code PC117** **£11.95**

HIGH POWER AUDIO AMPLIFIER CONSTRUCTION
R. A. Penfold

Practical construction details of how to build a number of audio power amplifiers ranging from about 50 to 300/400 watts r.m.s. includes MOSFET and bipolar transistor designs.

96 pages **Order code BP277** **£4.49**

Circuits, Data and Design

PRACTICAL ELECTRONIC FILTERS
Owen Bishop
This book deals with the subject in a non-mathematical way. It reviews the main types of filter, explaining in simple terms how each type works and how it is used.

The book also presents a dozen filter-based projects with applications in and around the home or in the constructor's workshop. These include a number of audio projects such as a rythm sequencer and a multi-voiced electronic organ.

Concluding the book is a practical step-by-step guide to designing simple filters for a wide range of purposes, with circuit diagrams and worked examples.

88 pages **Order code BP299** **£5.49**

DIGITAL ELECTRONICS – A PRACTICAL APPROACH
With FREE Software: Number One Systems – EASY-PC Professional XM and Pulsar (Limited Functionality)
Richard Monk
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Covers binary arithmetic, Boolean algebra and logic gates, combination logic, sequential logic including the design and construction of asynchronous and synchronous circuits and register circuits. Together with a considerable practical content plus the additional attraction of its close association with computer aided design including the FREE software.

There is a 'blow-by-blow' guide to the use of EASY-PC Professional XM (a schematic drawing and printed circuit board design computer package). The guide also conducts the reader through logic circuit simulation using Pulsar software. Chapters on p.c.b. physics and p.c.b. production techniques make the book unique, and with its host of project ideas make it an ideal companion for the integrative assignment and common skills components required by BTEC and the key skills demanded by GNVQ. The principal aim of the book is to provide a straightforward approach to the understanding of digital electronics.

Those who prefer the 'Teach-In' approach or would rather experiment with some simple circuits should find the book's final chapters on printed circuit board production and project ideas especially useful.

250 pages (large format) **Order code NE28** **£19.99**

A BEGINNER'S GUIDE TO TTL DIGITAL ICs
R. A. Penfold
This book first covers the basics of simple logic circuits in general, and then progresses to specific TTL logic integrated circuits. The devices covered include gates, oscillators, timers, flip/flops, dividers, and decoder circuits. Some practical circuits are used to illustrate the use of TTL devices in the "real world".

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160 pages **Temporarily out of print**

PIC YOUR PERSONAL INTRODUCTORY COURSE SECOND EDITION John Morton
Discover the potential of the PIC micro-controller through graded projects – this book could revolutionise your electronics construction work!

A uniquely concise and practical guide to getting up and running with the PIC Microcontroller. The PIC is one of the most popular of the microcontrollers that are transforming electronic project work and product design.

Assuming no prior knowledge of microcontrollers and introducing the PICs capabilities through simple projects, this book is ideal for use in schools and colleges. It is the ideal introduction for students, teachers, technicians and electronics enthusiasts. The step-by-step explanations make it ideal for self-study too: this is not a reference book – you start work with the PIC straight away.

The revised second edition covers the popular reprogrammable EEPROM PICs: P16C84/16F84 as well as the P54 and P71 families.

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Project Building & Testing

ELECTRONIC PROJECTS FOR EXPERIMENTERS
R. A. Penfold
Many electronic hobbyists who have been pursuing their hobby for a number of years seem to suffer from the dreaded "seen it all before" syndrome. This book is fairly and squarely aimed at sufferers of this complaint, plus any other electronics enthusiasts who yearn to try something a bit different. No doubt many of the projects featured here have practical applications, but they are all worth a try for their interest value alone.

The subjects covered include:- Magnetic field detector, Basic Hall effect compass, Hall effect audio isolator, Voice scrambler/descrambler, Bat detector, Bat style echo location, Noise cancelling, LED stroboscope, Infra-red "torch", Electronic breeze detector, Class D power amplifier, Strain gauge amplifier, Super hearing aid.

138 pages **Order code BP371** **£5.45**

ELECTRONIC PROJECT BUILDING FOR BEGINNERS
R. A. Penfold
This book is for complete beginners to electronic project building. It provides a complete introduction to the practical side of this fascinating hobby, including the following topics:

Component identification, and buying the right parts; resistor colour codes, capacitor value markings, etc; advice on buying the right tools for the job; soldering; making easy work of the hard wiring; construction methods, including stripboard, custom printed circuit boards, plain matrix boards, surface mount boards and wire-wrapping; finishing off, and adding panel labels; getting "problem" projects to work, including simple methods of fault-finding.

In fact everything you need to know in order to get started in this absorbing and creative hobby.

135 pages **Temporarily out of print**

PRACTICAL FIBRE-OPTIC PROJECTS
R. A. Penfold
While fibre-optic cables may have potential advantages over ordinary electric cables, for the electronics enthusiast it is probably their novelty value that makes them worthy of exploration. Fibre-optic cables provide an innovative interesting alternative to electric cables, but in most cases they also represent a practical approach to the problem. This book provides a number of tried and tested circuits for projects that utilize fibre-optic cables.

The projects include:- Simple audio links, F.M. audio link, P.W.M. audio links, Simple d.c. links, P.W.M. d.c. link, P.W.M. motor speed control, RS232C data links, MIDI link, Loop alarms, R.P.M. meter.

All the components used in these designs are readily available, none of them require the constructor to take out a second mortgage.

132 pages **Order code BP374** **£5.45**

RADIO BYGONES

We also carry a selection of books aimed at readers of *EPE*'s sister magazine on vintage radio *Radio Bygones.* These books include the *Comprehensive Radio Valve Guides* (five books with a Free copy of the Master Index) for just £15. Also Jonathan Hill's excellent *Radio Radio,* a comprehensive book with hundreds of photos depicting the development of the British wireless set up to the late 1960s.

The three volumes of our own *Wireless For the Warrior* by Louis Meulstee are also available. These are a technical history of radio communication equipment in the British Army from pre-war through to the 1960s.

For details see the shop on our UK web site at **www.epemag.wimborne.co.uk** or contact us for a list of *Radio Bygones* books.

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NOTE: While 95% of our boards are held in stock and are dispatched within seven days of receipt of order, please allow a maximum of 28 days for delivery – overseas readers allow extra if ordered by surface mail.

Back numbers or photostats of articles are available if required – see the *Back Issues* page for details. We do not supply kits or components for our projects.

Please check price and availability in the latest issue.

A number of older boards are listed on our website.

Boards can only be supplied on a payment with order basis.

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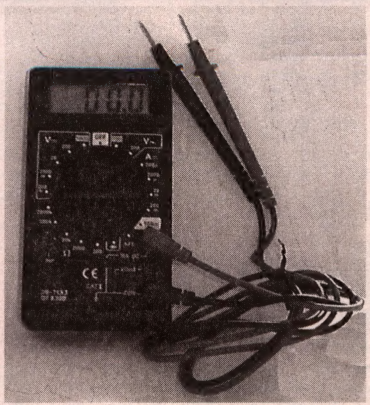

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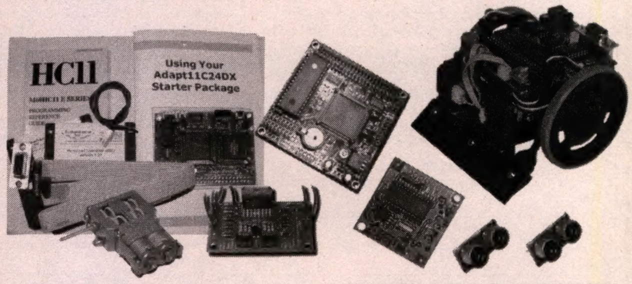

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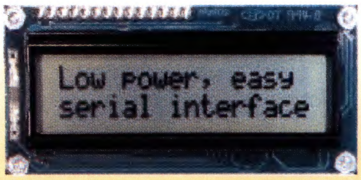

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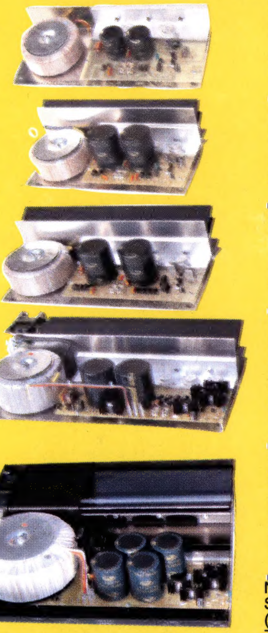

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